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THE PRACTICAL APPLICATION OF SCIENTIFIC MANAGEMENT TO RAILWAY OPERATION.

BY

WILSON E. SYMONS,

Chicago, Ill.

So much has been written and said on the subject of "Scientific Management of Railways" and the remarkable economies that either have been or can be accomplished in railway operations by "efficiency engineers," that the reading public no doubt feels that our railways are, with one or two rare exceptions, very inefficiently managed. The testimony taken at the hearing before the Interstate Commerce Commission in the recent rate case together with the numerous newspaper and magazine articles by the very able advocates of this plan all tend to show that, by the adoption of "scientific management" in the operation of our railways, a saving of *one million dollars per day* could easily be effected, and, as this information, so widely circulated, has no doubt carried partial or complete conviction to many who have not paused to consider the question of the practicability of this plan to all branches of railway operation, it will be the purpose of the writer to treat the question from the broad standpoint of a highly efficient transportation unit, to which all branches or integral parts must be subordinated.

It also seems quite proper in this connection to analyze some of the misleading figures and statements presented through the columns of one of our leading magazines in support of the general adoption of this plan, and to offer a very fitting, though tardy,

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recognition of efficiency engineering results already accomplished in the railway and industrial world.

The physical operation of a railway is in reality the management of a great manufacturing plant, the product being transportation; therefore the complete working *unit* or *plant* which accomplishes in the best or most economical and satisfactory manner the purposes or objects for which it was created and is operated is the most efficient one, although the complete unit may, if measured by the standards followed in some specific subordinate branch of the work, appear inefficient or wasteful, when in reality such may not be the case.

Years of valuable training as the head of, and responsible for, one of the most important departments in a complete operating unit give a clear angle of vision, which, to the eye of the shop specialist, is slightly in *eclipse*. And it is due to this fact that many features of "scientific management," while admittedly correct from a theoretic standpoint, are not practical. Such portion or percentage of the working forces and expense as can be handled under this plan is so very small, in comparison to the complete unit, that the term "scientific management of *railways*" is a misnomer.

To be more specific, the physical management or operation of a railway consists largely in the direction or handling of large bodies of men of various classes, characteristics, and conditions, together with numerous phases of industrial life and human endeavor, while the purely scientific problems consist largely in the application of fixed rules or formulas in the office, laboratory, or drawing-room, and it should be clear to all who have been charged with, or have participated in, the solution of transportation problems, that those best equipped for scientific work are not, as a rule, well suited to grasp the multiplicity of complex features embraced in railway management.

Having thus differentiated as to the character of work involved in the complete transportation unit, and consequently the essential qualifications of those best fitted to direct the various branches of the work, it is quite proper to present in comprehensive statistical form the magnitude of our railways considered as one.

STATISTICS.

Attention is invited to the following tabulated displays of mileage, equipment, and capitalization, officers and employees

classified, volume of business handled, income and expenses subdivided, and the estimated number of men and amount of saving that might reasonably be expected from the introduction, in a modified form, of the "scientific management" plan.

MILEAGE EQUIPMENT AND CAPITALIZATION.

Mileage, main line (1909)	235,000
Mileage, extra tracks, yards, and sidings	107,000
Total	342,000
Locomotives	58,000
Passenger cars	45,584
Freight cars	2,250,000
Number security holders	1,000,000
Representing (5 to 1)	5,000,000 people
Or about 5½ per cent. of	90,000,000 people
Total capitalization	$13,700,000,000
Capitalization per mile, about	$60,000

TABLE A.

NUMBER OF OFFICERS AND EMPLOYEES BY CLASSES AND THEIR COMPENSATION

Class	1909					1907	
	Number of Employees and % of Each		Total Yearly Compensation		Avge. Daily Compensation	Total Yearly Compensation (1907) and Average Daily Rate	
	Number of Each Class	%	Amount to Each Class	%		Amount to Each Class	Daily Rate
General Officers	5,492		$16,574,587		12.67	$17,231,606	11.93
Other Officers	8,022		17 241,799		6.40	15.012,226	5.99
Gen'l Office Clerks	69,595		52,516,034		2.31	48,340,123	2.30
Station Agents	36,519		25,881,387		2.08	24,831,066	2.05
Other Sta. Men	136,733		79,089,030		1.82	84,244,486	1.78
Enginemen	57,077		78,988,116		4.44	87,496,778	4.30
Firemen	60,349		48,294,077		2.67	52,474,059	2.54
Conductors	43,608		51,873,772		3.81	55,847,244	3.69
Other Trainmen	114,760		89,710,526		2.59	99,978,356	2.54
Machinists	48,237		41,731,839		2.98	46,475,695	2.87
Carpenters	60 867		43,420,646		2.43	49,082,659	2.40
Other Shopmen	195,110		119,909,837		2.13	132,421,765	2.06
Section Foremen	41,859		27,405,664		1.96	26,326,635	1.90
Other Trackmen	320,762		110,769,229		1.38	135,793,476	1.46
Sw. Ten. Crossing Watchmen	44,698		25,521,433		1.73	32,184,636	1.87
Tel. Op's & Dispt.	39,115		29,689,851		2.30	29,058,251	2.26
Employees Float. Equipment	8,758		6,597,867		2.31	6,035,415	2.27
All other Employees & Laborers	210,898		122,901,000		1.98	129,551,951	1.92
Total	1,502,823	100	$988,323,694	100		$1.072,386,427	

Number of employees in 1907, 1,672,074, or 169,249 more men on 227,671, or 7,329 less miles than in 1909

Having shown in the foregoing tabulated form the number of officers and employees, their total yearly and average daily

TABLE B.

OPERATING REVENUES

Items	Amount	Proportion to total operating revenues
Tons freight carried one mile	29,109,322,589	
Passengers carried one mile	218,802,986,929	Per cent.
Freight Revenue	$1,677,614,678	69.32
Passenger Revenue	563,609,342	23.32
Mail Revenue	49,380,783	2.04
Express Revenue	59,647,022	2.47
Express Baggage and Milk	13,694,171	.57
Parlor and Chair Car	3,989,612	.17
Switching Revenue	21,599,256	.89
Special Train and Miscellaneous Transp	7,833,852	.33
Total Outside of Transportation	19,756,577	.82
Joint Facilities—Dr	500,301	.02
Joint Facilities—Cr	2,052,546	.09
Total	$2,418,677,538	100
THIS WAS EXPENDED AS FOLLOWS		
Maintenance Way and Structures	$ 308,450,105	19.29
Maintenance Equipment	363,912,886	22.75
Traffic Expenses	49,287,148	3.08
Transportation Expenses	814,088,149	50.90
General Expenses	63,677,378	3.98
Unclassified	27,744	
Total	$1,599,443,410	100

Net Income from Operations		$819,234,128
Income from Investments	$73,586,827	
Salaries and Maintenance Leased Lines	406,309	
		73,993,136
Net Revenue and Income		892,414,646
Interest and Taxes		478,802,168
Available for Dividends, Improvements, etc		613,612,478
Net Dividends		236,620,890
Available for Adjustments and Improvements		*176,991,588

* It has been estimated that the economies practised in 1908 and 1909 resulted in arrears in maintenance of over $200,000,000, or about $15,000,000 more than the surplus available, which sum contains items from sources other than operation.

compensation, it will now be in order to cast up, in comprehensive form, a display of the results of their labors, or a statement of operations.

In the following tabulated display showing division of operating expenses the amounts charged to each are shown, together with the ratio or percentage such item bears to the whole.

TABLE C.

DIVISION OF OPERATING EXPENSES

Items	Amount	Proportion to Total Operating Expenses
Maintenance of Way and Structures	$308,450,105	19.29
Maintenance of Equipment	363,912,886	22.75
Traffic Expenses	49,287,148	3.08
Transportation Expenses	814,088,149	50.90
General Expenses	63,677,378	3.98
Unclassified	27,774	
Total	$1,599,443,410	100%

First item excludes returns for switching and terminal companies and a few roads whose reports were incomplete, the amount not included being about $247,700.

GENERAL BALANCE SHEET, JUNE 30TH, 1909.—221, 679.45 MILES.

Items	Assets	Items	Liabilities
Cost of Road	$12,222,830,405	Capital Stock	$ 7,576,335,321
Cost of Equipment	1,228,620,996	Funded Debt	9,739,127,869
Gen'l Expenditures	157,732,114	Current Liabilities	1,065,184,870
Stocks Owned	2,246,702,598	Miscellaneous	884,159,190
Funded Debt Owned	1,229,683,954	Profit and Loss	800,642,923
Cash&CurrentAssets	1,349,131,087		
Material & Supplies	206,849,619		
Sinking, Insurance and other Funds	169,877,287		
Miscellaneous	1,254,022,113		
Total	$20,065,450,173	Total	$20,065,450,173

From the foregoing Balance Sheet it may be noted that the valuation placed on the physical property (221, 679 miles) is..... $13,658,301,100
By including the additional 13,321 miles at $60,000 per mile we have the following: 13,321 x $60,000 = 799,260,000

Or, a grand total (in 1909) of over..... $14,457,561,000

ANALYSIS AND SALIENT POINTS IN THE FOREGOING STATISTICAL DATA.

From the foregoing tabulated statistical data the following potent factors stand boldly out:

That there are ..... 235,000 miles of railway
That the valuation is about $14,457,561,100
That there are ..... 58,000 locomotives
That there are ..... 45,584 passenger cars
And about ..... 2,250,000 freight cars
That there were carried one mile ..... 29,109,322,589 tons of freight
That there were carried one mile ..... 218,802,986,929 passengers
That the revenue from operation was $2,418,677,538
That the expense of operation was $1,599,443,410
That the number of officers and employees was 1,502,823
That their combined salaries was $988,323,694

SAVE $1,000,000 PER DAY.

And it is proposed by the application of "scientific management" to save one million dollars per day, or approximately $365,000,000 per year.

Although it is claimed this new plan or system is applicable to most all items of expense (material and labor used) on a railroad, the estimated probable economies will, in this treatment of the question, be confined to such branches of the work, or classes of employment, as in my judgment are susceptible of being placed on a comparative basis with large manufacturers of standard articles.

TOTAL YEARLY COMPENSATION—OFFICERS AND EMPLOYEES.

The total yearly compensation of all officers and employees (1,502,823 persons) in 1909 was $988,323,694, and by a process of elimination, the number of employees and amounts earned, to which the plan contemplated may be partially applied, can be arrived at by treating each class separately.

PROCESS OF ELIMINATION.

First: Referring to Table A, we will take the first two items, *General Officers* and *Other Officers*

Total, 13,514.....compensation, $33,816,386,

that would not be subject to this plan.

Second: General Office Clerks, of whom there are

69,959 persons.....compensation, $52,516,034,

that would not come under this system.

Third: Station Agents, of whom there are

36,519 persons.....compensation, $25,881,387.

These would not apply.

Fourth: Engineers, Firemen, Conductors, and *Other Trainmen,* of whom there is a total of

275,794 persons.....compensation, $268,866,491,

to whom this plan will not apply, as they are *all* working under contracts that will undoubtedly be kept in good faith by the companies. The amount of their earnings fluctuates with the volume of business.

Fifth: Section Foremen, of whom there are

41,859 persons.....compensation, $27,405,664,

to whom this would not apply. There are only 468 more foremen now than in 1907, to handle 13,321 additional miles of road, and their average daily rate of pay has increased from $1.90 to $1.96, or 6 cents per day, while their duties have materially increased.

Sixth: Other Trackmen, of whom there are

320,760 persons.....compensation, $110,769,229,

to whom this plan would not apply, as the grade of men and character of their work will not lend itself to any such scheme. There are, it may be noted, 46,517 less in number than in 1907, and their average daily earnings have dropped from $1.46 to $1.38, or a reduction of 8 cents per day.

Seventh: Switch Tenders and Crossing Watchmen, of whom there are

44,698 persons.....compensation, $25,521,433,

to whom this plan would not apply, as there are 8716 less in number than in 1907, and their average daily rate has dropped

from $1.87 to $1.73, or 14 cents per day. Again, these men are largely of a disabled class who have served their companies during the prime of life in more responsible positions.

Eighth: Employees Floating Equipment, of whom there are

8,758 persons.....compensation, $6,597,867,

who would not be affected by this plan, as most of them come under our Federal Steamboat Inspection Law requirements, and their daily average wage rate of $2.31 will not admit of reduction.

Ninth: Telegraph Operators and Dispatchers, of whom there are

39,115 persons.....compensation, $29,896,851
Less estimated reduction of 15 per cent..... 4,484,527

$25,412,324

By the use of telephone for train movement and a more liberal supply of common sense in the transaction of the companies' business by *letter* (and a less number of letters) in place of telegrams this can be reduced 15 per cent., or to $25,412,324. This, however, is not a subject for any scientific study whatever, but calls for the attention of a good, practical railroad man.

Tenth: Carpenters, of whom there are

(1907) 70,394
(1909) 60,867 persons.....compensation, $43,420,646

9,527 less than in 1907.

The plan in question would apply to very few of these, if any, as they are now among the poorest paid employees on a railroad, due to the fact they are not organized. There are 9527 less in number than two years ago, and their average daily rate has only increased 3 cents per day, or from $2.40 to $2.43.

Eleventh: All Other Employees and Laborers, of whom there are

(1907) 228,324
(1909) 210,898 persons.....compensation, $122,901,000

17,426 less than in 1907.

The plan in question would not apply to this mixed class, as it includes the raw recruit, the man of migratory habits, and the "hobo," most of whom are of a low order of mentality, and some dissipated. Increased supervision by practical men is the only means of increasing their efficiency, or quantity of work performed. There are 17,426 less in number than in 1907, and their daily rate has only increased 6 cents, or from $1.92 to $1.98 per day.

Twelfth: Other Stationmen, of whom there are

(1907) 152,929
(1909) 136,733 persons.....compensation, $79,089,030

16,196 less than in 1907.

The plan would not apply to this class, although such increased and improved facilities as the managers have been providing, as finances will permit, from time to time, and will doubtless continue in future, will make it possible to take care of some considerable increase in the scope and volume of station work without materially increasing the number of employees. There are now 16,196 less in number than in 1907, while their rate per day has increased 4 cents, or from $1.78 to $1.82 per day.

By the foregoing process of elimination the various classes of officers and employees have all been considered except two, which will come next in turn.

The classes disposed of, and the amount of their total yearly compensation, are as follows:

Number classes disposed of	16
Employees embraced	1,359,476
Classes yet to be considered	2
Number of employees embraced	243,347
With a total yearly compensation of	$161,641,676

TWO CLASSES.

The two classes yet to be considered are:

Machinists	48,237	Compensation	$41,731,839
Other shopmen	195,110	Compensation	119,909,837
Total	243,347	Total	$161,641,676
Per cent. of all			16

By the foregoing process approximately 84 per cent. of the total employees and expenditure for labor has been disposed of without locating any economies that would yield only to the "scientific management" plan.

The one item of $4,484,527 on page 12, "Telegraph Operators and Dispatchers," is one that an experienced, practical railway officer would see and take advantage of, while the plan considered is not applicable to this class of employees.

Returning to the two classes of employees comprising the remaining 16 per cent., or 243,347 employees, it may be stated, first, that these include, among others, the following:

Machinists	Coachbuilders
Boilermakers	Upholsterers
Blacksmiths	Cabinetmakers
Coppersmiths	Freight car builders
Sheet metal workers	Freight car repairers
Tinners	Passenger car repairers
Painters	Apprentices, handy men, helpers, etc.

A large majority, say 75 to 80 per cent., of these men are thoroughly organized and quite aggressive. They are also, in most cases, working under contracts that are jealously guarded.

While, no doubt, there is room for improvement in the shops of all railway companies, the condition is one calling for, and that will yield to, such remedial measures as the progressive mechanical officers of our railways are applying as fast as the managements permit them to incur the expenditures necessary.

Additional shops, machinery, tools, tracks, material, increased supervision and office help are needed on most all roads.

There is *nothing scientific about this;* it is simply a plain, common sense business proposition.

The maintenance of equipment, or its current upkeep, is not all work of such a character that it is susceptible of predetermination as to method of operation, or cost, and cannot, therefore, be reduced to writing, blue-print or graph, but must be handled by the experienced, practical man, who, usually, like the skilled surgeon, decides on the exact method or details of procedure while gathering instruments, tools, and material to perform an operation.

The proposition to apply "scientific management" to all running repairs of railway equipment, especially locomotives,

is not only impractical, but strongly emphasizes its advocates as lacking in the elementary knowledge of locomotive operation and maintenance essential in advising or directing others.

As the current running repairs to railway equipment are of a character calling for treatment by competent, experienced mechanics, the possible economies from the adoption of "scientific management" must necessarily be confined to the main shops of such companies as are large enough to maintain, and have in operation, one or more general shops entirely *independent of,* and *separate from,* their running repair shops. In these large shops locomotives and cars in considerable number are built new, or rebuilt, on such scale that much of the work is of the character of that in a manufacturing plant where workmen are principally machine operators or tenders, and are not required, or permitted, to exercise any mechanical skill or initiative in preparing for or executing the work.

The number of men, even in a large central railway shop, who continually perform the same, or similar, operation, and in the same manner, are comparatively few.

IMPRACTICABILITY OF "SCIENTIFIC MANAGEMENT" IN HANDLING THE RUNNING REPAIRS THAT ACCRUE FROM SERVICE.

To those familiar with operating requirements of railways an apology is due for using time or space in the presentation of matter embodying details which, to them, are well-known facts, and your indulgence is asked with the hope that the matter presented may be of interest, or value, to many who are interested in the subject, but may not have had the necessary practical experience in actually doing the things talked of to enable them to fairly judge as to the merit, or demerit, of disputed points.

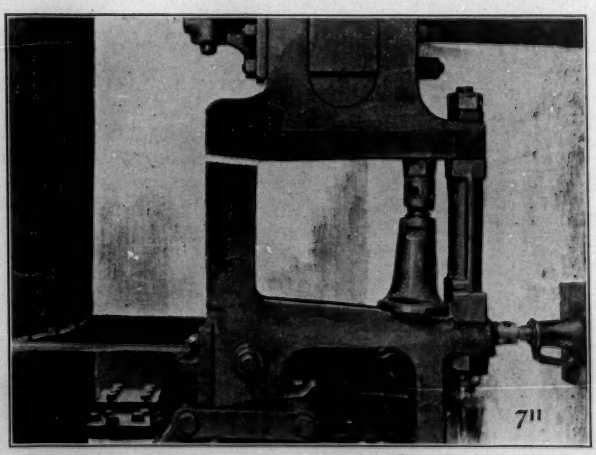
CHARACTER OF LOCOMOTIVE REPAIRS.

That there may be no doubt as to the extremely difficult and varying character of repairs that accrue from service, and enter largely into the cost of locomotive maintenance, each of which requires some special treatment, the following views (Plates D) are offered to amplify what has been said on the subject.

PLATE D1.

Showing fractured part of locomotive cylinder.

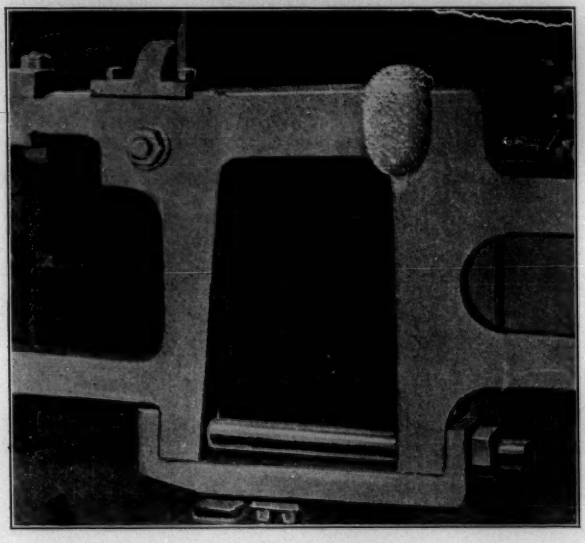
PLATE D2.



Showing fracture in locomotive frame.

The character of repairs made necessary by the foregoing conditions renders it absolutely essential to successful operation that both the foreman in direct charge of each operation, and the mechanic who is actually performing the work, shall not only be *permitted* but *required* to bring into use their mechanical skill

PLATE D3.



Showing locomotive frame after repairs.

and judgment, which, under the proposed plan of "scientific management," they would be prevented from doing.

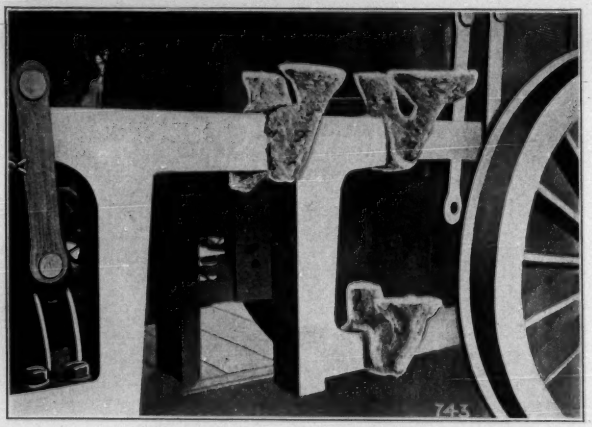
In addition to the foregoing examples, there are numerous other operations in the repairing of locomotives, the same each day by *description*, but entirely different in the matter of *time, physical effort, material,* and *mechanical skill employed* in their completion. It may be stated, as a fact, that these operations are seldom ever exactly alike, except in name or description.

Among the more common operations that go to make up locomotive repairs are the following:

Repairs to, or renewals of, revolving and reciprocating parts, such as rods, guides, pistons, piston rods, cross-heads, valves, valve gear, truck and tank wheels and drivers; driving boxes, shoes and wedges, frames, cylinders, steam chests, and covers; air pump and brake apparatus, truck frames, headlights, boiler and front end complete, cab and cab fittings, tender complete, etc.

There is also a great variety in the character of repairs to both passenger and freight cars.

PLATE D4.



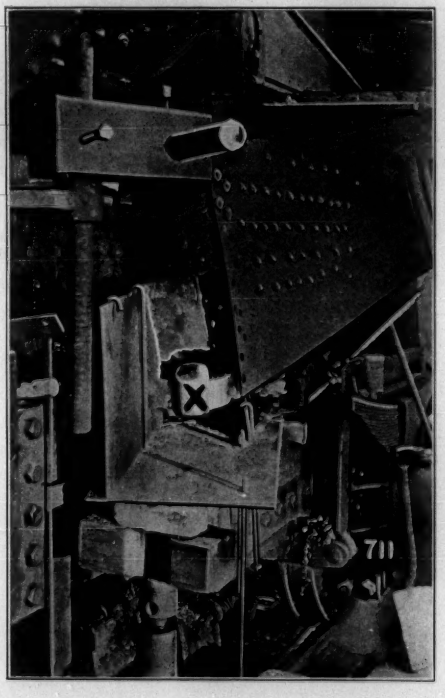
Showing locomotive frame welded in three places.

To establish an arbitrary time limit, in advance, for the completion of all these operations, particularly locomotive work, based on time studies of each "body movement" from commencement until completion of certain trial test operations, practically eliminates the operator's or mechanic's personality, transforming him from a skilled mechanic into that of *factotum* or machine, and the foreman in charge only one grade higher, but in the same class.

Such a system would have a tendency to discourage both men and officers from that personal initiative essential to a *strong, efficient* and *economical* organization.

Some form of measured output, based on compensation, such as task or piecework plan, fair and just alike, *first*, to the *men*, and *second*, to the *company*, to be used at such points as operating

PLATE D5.



Showing broken fire-box and ring ready for welding.

conditions will permit, and with sufficient amount of competent supervision over the working forces at all points to insure *good, efficient service*, is a far superior plan, and would yield handsome returns where the so-called "scientific management" plan would not only fail to give the results claimed, but prove an *expensive experiment*.

SUMMARY OF ECONOMIES.

The two classes, shown on page 13, yet to be disposed of, are as follows:

	Number men	Amount compensation
Machinists	48,237	$41,731,839
Other shopmen	195,110	119,909,837
Total	243,347	$161,641,676

We, therefore, have yet to consider the above item, which is 16 per cent. of the operating expense.

On large roads maintaining extensive shops where the construction of new, and rebuilding of present, equipment is carried on to a considerable extent, the number of men who are regularly engaged on a fixed class of work that would lend itself to the proposed "scientific management" plan has been estimated at 10 to 12 per cent. of the mechanical department forces, while as a matter of fact the actual number is much less, but in order to be more than liberal, the figure will be placed at 15 per cent., and this applies to both the *machinists* and *other shopmen*, although the duties of other shopmen are of such a diversified character that there is probably less than 5 per cent. to whom this plan could be applied.

Summing up on the foregoing basis of 15 per cent. on three items, however, we have the following figures:

Class	Number employees	Number to be laid off or discharged	Amount to be saved in dollars	Average saving per day
Operators	39,115	5,867	$4,412,324	
Machinists	48,237	7,235	6,259,675	
Other Shopmen	195,347	29,302	17,986,475	
Total	282,699	32,404	$28,658,474	$78,242.00

Instead of $1,000,000 per day we have $78,242, and this is predicated, or conditioned, on the assumption that such additional tools, shops, supervision, etc., be provided as to enable the officers in charge to secure a greater output on the same expenditure, or the same output at a less expense, and that the organization of the department be on lines calculated to strengthen the hands

of the line officers in charge, who, in the last analysis, are always held responsible for results.

CONSERVATISM OR LACK OF MORAL COURAGE.

It is a traditional characteristic of the human race that they will submit to continued hardship, loss, and suffering, rather than undergo a change from time-worn precedents, and even though seeking relief are slow to adopt remedial measures when presented; in fact, as individuals and corporations, many of us move so ultra-conservative that it is a wonder that we do not *fall over backward*.

Any material change in the methods of operation on railways usually results either in improvement or injury to the organization, and consequently affects its efficiency or *earning power*. It is, therefore, the part of wisdom to move with at least ordinary business caution in approaching a proposition of such moment in the company's affairs, for even a bold, aggressive management seldom accepts a theory which has not become a demonstrated fact.

Recently there has been much written with respect to "scientific management" as applied to railway operation, and as proof of its merits the Santa Fe Railway is cited as an example, and the very extraordinary economies claimed are mentioned in detail, and approximate standards of cost for the maintenance of locomotives and freight cars are given. I wish at this time to state, however, that in the presentation of statistical data from the annual reports of the Santa Fe Railway Company or in any comments or criticisms of the results on this line in comparison with other lines, the sole purpose is to show to what extent Scientific Management has actually operated to the company's benefit in the item of equipment maintenance. The conclusions in no case are intended for, and should not be construed as any reflection on the ability of the officers in charge of this splendid property.

ANALYSIS OF RESULTS ON THE A., T. & S. FE.

In order to present a clear understanding of all items of expense shown in the following statistics, it is proper to review conditions on the Sante Fe *prior* to the introduction of "scientific management" in their shops, and up to the present time.

During the year 1901–02 there was constant evidence of discontent on the part of the shopmen generally throughout the West, and a few local strikes occurred at different points on the western portion of the Santa Fe lines. All were of rather short duration except the one on the company's lines in Texas, which included all shopmen, except carmen, and continued for many weeks, the men being finally defeated.

This, however, proved only to be the forerunner of a general strike on the entire Santa Fe system, which took effect in May, 1904. It was a most bitterly fought contest, and like all kinds of *war*, no matter where waged, in the drawing-room, the counting-house, in Wall or Lombard Street, on the high seas, on the field of battle, or between organized labor and a corporation, they *cost money* in proportion to the size or strength and determination of the contending parties.

It is unnecessary to dwell on the cost of the strike to the Santa Fe at any *great* length; that it was extraordinary, however, is evidenced by the fact that, as a result, the cost of locomotive maintenance advanced, as follows:

Years	Number of engines	Cost per engine per yr.	Increase over 1900
1900	1,136	$2,096	
1901	1,174	2,858	
1902	1,312	3,156	
1903	1,309	3,041	
1904	1,433	3,772	
1905	1,454	4,165	98.7%

It should be noted that the cost of locomotive maintenance in 1905 above 1903, the year prior to the general strike, was 37 per cent., or $1,634,296, this item being one of the essential factors in determining the economic effect of "scientific management" on the cost of maintenance, but on which the advocates of this plan have so far remained *painfully silent*, even when quoting figures affected thereby, thus conveying the impression that conditions were normal in 1905, and thereby taking credit for the reduction in cost per engine, to $3101 in 1906 and $3036 in 1907, that was bound to follow the termination of this struggle, thus changing the basis of company's financial budget or maintenance item from a *war* to a *peace* basis.

TABLE E.

TABLE. MECHANICAL DEPARTMENT. STATISTICS 1900 TO 1910 INCLUSIVE

STRIKE PERIOD

	ITEMS	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	PER CENT OF INCREASE OVER 1900.	PER CENT INCREASE 1904-5-6-&7. OVER FOUR NYRS. PRIOR
1.	NUMBER OF ENGINES.	1136	1174	1312	1309	1433	1454	1676	1791	1872	1872	1923	68.	28.7
2.	NEW ENGINES BOUGHT	109	52	207	75	156	37	192	128	81		54 TOTAL	1,085	
3.	NUMBER OF PAS'CARS.	665	717	782	801	861	881	995	1135	1193	1176	1375	77.	
4.	" - FRT. -	28,042	29229	34201	36432	39072	39171	44204	49770	55108	54698	57781	97.	34.
5.	" - WORK "	688	739	1387	1327	1201	139	148	221	292	298	495		
6.	LOCO: MILEAGE. TOTAL	36,652,980	39,796,243	40,771,235	39,932,405	40,295,707	40,176,636	45,694,524	51,510,692	50,428,092	48,874,635	57,038,087	56.	13.4
7.	COST. MAINTNCE LABOR	$ 1,575,660	1,997,728	2,433,463	2,362,040	3,000,122	3,356,963	2,739,195	2,800,250					
8.	COST " MATERIAL	$ 858,379	1,264,648	1,278,734	1,099,035	1,570,182	1,759,608	1,662,354	2,050,004					
9.	COST " TOTAL.	$ 2,434,039	3,262,376	3,712,197	3,461,075	4,570,304	5,116,571	4,401,550	4,850,256	6,590,743	5,490,346	6,896,894	183.3	46.3
10.	MILE S TON OF COAL	20.36	18.48	17.43	15.46	14.48	14.70	14.70	13.63	13.19	13.78	13.50	REDUCTION 33.6	REDUCTION 19.1
11.	" - " - OIL.	20.3	21.	22.80	22.80	21.59	19.82	24.48	23.14	22.02	22.65	21.39		
12.	" - PINT OIL LUB:	12.21	16.32	13.56	12.57	11.93	12.04	12.09	11.36	11.63	13.32	13.33		
13.	NEW ENGS & CARS. COST OF	1,065,675	992,899	6,807,494	3,548,428	4,461,304	58434	8,994,478	8,843,531	9,739,096	1,249,072	12,432,369	131.	80.
14.	SHOP MACHY & TOOL. ADDT'NS	$ 157,838	162,572	68,756	363,494	137,859	137,023	190,198	73,981	186,072	22,720	109,978		
15.	SALARIES GEN'L OFFICERS	$ 216,701	262,829	356,577	330,341	357,522	336,752	379,420	432,577	251,154	233,844	408,424	88.5	26.6
16.	" CLERKS & ATTEND'S.	$ 355,477	381,693	502,657	561,099	615,650	668,582	710,123	825,041	803,972	870,590	948,753	164.	56.5
17.	MAINTNCE EQUIPT SUPERTDTS	$ 49,432	50,342	218,228	310,016	326,217	361,555	446,287	599,290	433,664	429,606	534,564	981.	152.6
18.	LOCO'S REPAIRS & RENEWS	2,381,155	3,205,178	3,713,584	3,461,075	4,570,305	5,116,571	4,401,550	4,697,673	6,590,743	5,490,346	6,896,894	63.6	55.3
19.	COST PER ENGINE.	$ 2,096	2,858	3,156	3041	3,112	4,165	3,101	3036	3,713	3,132	3832	82.8	26.8
20.	COST PER MILE CENTS.	.663	.819	.91	.997	.1342	.1487	.1108	.108	.1374	.1195	.1287	94.4	42.5
21.	PASS' CARS REPRS & RENEWS	$ 351,086	486,146	538,263	586,803	605,129	825,895	728,373	897,456	1,156,766	1,246,503	1,610,870	353.	55.
22.	COST PER PASS' CAR.	$ 550	728	829	872	873	1,132	888.6	963	1040	1134	1249.	127.	34.7
23.	COST PER PASS. CAR. MILE.	¢			.009	.0091	.0113	.0088	.0100	.0111	.0117	.0136		
24.	FRT. CARS REPRS & RENEWS	2,273,064	2,263,720	2,627,062	3,188,886	3,019,903	3,099,635	3,984,406	4,415,645	5,506,045	6,218,693	5,916,903	164.	42.
25.	COST PER FRT. CAR.	$ 81.	79.	85.	100.70	93.24	93.66	103.71	102.68	105.54	120.41	108.23	36	13.7
26.	COST PER FRT. CAR MILE.	¢			.007	.0076	.0078	.0083	.0083	.0100	.0111	.0091		
27.	WORK CARS. REPRS & RENEWS	$		106,061	127,792	144,350	124,908	137,563	136,750	191,803	98,636	154,713		
28.	SHOP MACH'S & TOOLS MTC'CE	$ 134,162	181,168	283,846	401,809	487,170	486,620	367,474	315,844	290,832	289,633	236,696	76.	67.5
29.	OTHER EXPENSES.	$	129,370.	239,753	386,652	718,435	817,055	563,536	611,744	31,423	3,960	3413		258
30.	TOTAL MAINTNCE EQ'PT	$ 5,261,832	6,257,456	7,864,951	8,510,543	10,006,135	10,914,864	10,720,040	11,719,846	14,316,338	13,903,897	15,560,047	149	50.
31.	EXPENDITURE PER MILE.	$ 717.50	801.49	1,001.22	1068.48	1223.31	1314.19	1271.05	1270.32	1,513.18	1419.51	1,569.13	118.6	41.5
32.	TONS FRT LOADED CAR MILE	12.67	12.60	13.68	14.15	13.87	14.05	14.65	15.47	19.29	18.35	19.08	50.	
33.	" - PER TRAIN MILE	221.40	242.67	247.51	276.67	269.81	281.85	307.37	320.00	366.54	366.06	388.80	60.3	
34.	AVER TRAC POWER PER ENG				22,526	25,578	26,217	27,684	29,225	29,757	29,714	29,803.		
35.	" WGT. ON DRIVERS.					58.63	58.75	61.27	62.66	63.12	63.76	64.04		
36.	MILEAGE.	7,341.	7,807	7,855	7,965	8,179	8,305	8,433	9,273.	9,415	9,794	9,916.		

ITEMS No. 15 AND 16. COVER ALL DEPARTMENTS.

Having reviewed the conditions up to 1905 with a view of making clear any comparisons with that or other years, a tabulated display of mechanical department expenses for the years 1900 to 1910, inclusive, is next presented, from which many interesting comparisons may be made and deductions drawn.

Referring to Table E, page 19, attention is invited to the following facts:

That the average cost of maintenance of locomotives, items 7, 8 and 9, was 47 per cent. greater during the years 1904, 1905, 1906 and 1907 than during the four years prior.

That the total average cost for maintenance of equipment (see item 30) was 50 per cent. greater in 1904, 1905, 1906 and 1907 than during the four years prior.

That general office clerks' expense increased 56 per cent.

That maintenance equipment superintendence expense increased 153 per cent.

That shop machinery and tools expense increased 67 per cent.

That cost of new engines and cars increased 80 per cent.

And the item of "Other Expenses" increased 258 per cent. during the four-year period of 1904–1905–1906–1907 as compared with the four years prior.

This comparison is intended to serve two purposes:

First: The abnormal high cost of maintenance in 1904 and 1905 *due to the shopmen's strike.*

Second: That with this abnormal *high* cost as a favorable starting point, together with the lavish expenditure of millions for new locomotives, cars, shop tools, supervision and *other* expenses, the showing for the four years mentioned, or even the three years following, 1908, 1909 and 1910, a total of seven years, has not at any time been as good as prior to the introduction of "scientific management" on the road in 1904.

OPERATING RESULTS IN COMPARISON.

With a view of presenting a comparison of certain operating results of representative lines, in the territory traversed by the A., T. & S. F. Ry., also in the United States, an additional table (F) was prepared, and your attention is first invited to section one of the comparative cost per engine per year and cents per

TABLE F.

SECTION ONE (1).

SHOWING THE COST PER ENGINES PER YEAR AND CENTS PER MILE RUN, ALSO AVERAGE TONS PER FREIGHT TRAIN MILE, PER CENT OF EARNINGS FROM FREIGHT REVENUE AND AVERAGE MILES PER ENGINE PER DAY ON TWELVE (12) LINES WEST OF CHICAGO.

	NAME OF ROAD	NUMBER OF LOCOMOTIVES AND COST PER YEAR FOR MAINTENANCE			AVERAGE NUMBER TONS FREIGHT PER TRAIN MILE	PER CENT OF TOTAL EARNINGS FROM FREIGHT (APPROX)	AVERAGE MILES PER ENGINE PER DAY
		NUMBER ENGINES	COST PER YEAR FOR MAINTENANCE	COST PER MILE RUN			
1	A.T & S.F.	1,923	$3,832	12.87	298.39	68	81
2	C.B & Q.	1,673	$3,087	9.99	381.26	66	85
3	C & N.W.	1,520	$2,527	6.92	260.71	66	100
4	C.M.&ST.P.	1,199	$2,523	6.57	275.68	68	116
5	C.R.I.&P.	1,429	$2,478	8.55	257.83	65	81
6	GT. NORTHERN.	1,118	$2,843	11.02	520.23	72	70
7	MO. PACIFIC RY.	530	$3,893	9.21	239.80	70	100
8	NORTHERN PACIFIC.	1,430	$2,481	12.86	429.28	65	76
9	ST.L.&S.F.	979	$2,923	10.81	386.40	68	74
10	M.K.&T.	541	$2,783	8.45	216.21	65	90
11	SOUTHERN PACIFIC.	1,218	$4,218	13.89	237.46	62	92
12	UNION PACIFIC.	689	$3,687	11.42	451.65	69	84
	TOTAL	14,249					
	AVERAGES		$3,148	10.18	311.24		
	PER CENT SANTA FE ABOVE AVERAGE			21%	25%		

SECTION TWO (2).

SHOWING COST OF SUPERINTENDENCE MAINTENANCE OF EQUIPMENT, THE RATIO THIS SUM BEARS TO THE NUMBER OF LOCOMOTIVES AND TO LOCOMOTIVES AND ALL CARS, LOCOMOTIVE MILEAGE AND COST PER MILE FOR SUPERINTENDENCE, COST PER YEAR TO MAINTAIN, COST PER MILE RUN FOR REPAIRS, AVERAGE MILES PER DAY PER ENGINE, PER CENTAGE OF ENGINE MILEAGE MADE IN PASSENGER SERVICE AND RATIO OF OPERATING EXPENSES TO OPERATING REVENUES.

	NAME OF ROAD	SUPERINTENDENCE MAINTENANCE OF EQUIPMENT YEAR---1910	SUPERVISION TO NUMBER OF LOCOMOTIVES AND ALL ENGINES AND CARS			LOCOMOTIVES, PASSENGER AND FREIGHT CARS, AND RATIO OF COST OF					LOCOMOTIVE MILEAGE AND COST PER MILE FOR SUPERVISION		COST OF MAINTENANCE PER YR & PER MILE		AVERAGE MILES PER ENGINE PER DAY	PER CENT OF ENGINE MILEAGE IN PASSENGER SERVICE (APPROX)	RATIO OF OPERATING EXPENSES TO OPERATING REVENUE
			NUMBER ENGINES OWNED	RATIO TO EACH ENGINE	NUMBER PASS. CARS	NUMBER FREIGHT CARS	NUMBER COMPANY CARS	NUMBER ALL CARS AND ENGINES	RATIO TO EACH UNIT	TOTAL LOCOMOTIVE MILEAGE	COST PER MILE FOR SUPERVISION CTS.	COST PER YEAR TO MAINTAIN	COST PER MILES CTS.			
1	A.T & S.F.	$534,564.48	1,923	$278	1,357	57,781	495	61,574	$8.65	57,038,081	.0094	$3,832	12.87	81	31	64.55
2	B & O.	$443,689.41	2,023	$220	1,157	83,693	3,970	90,868	$4.94	64,316,068	.0069	$3,131	10.00	82	26	68.99
3	C & N.W.	$224,606.55	1,520	$147	1,444	62,639	1,888	66,047	$3.40	35,323,343	.0044	$2,521	6.92	100	36	70.31
4	C.M & ST. P.	$133,715.42	1,199	$111	1,103	44,868	1,315	47,703	$2.80	47,345,806	.0028	$2,523	6.57	116	30	69.07
5	ERIE.	$257,663.06	1,398	$184	1,116	48,350	1,984	52,848	$4.87	29,807,613	.0086	$2,619	11.34	60	30	65.06
6	GT. NORTHERN.	$178,544.78	1,118	$159	860	44,283	1,666	47,927	$3.72	28,831,969	.0061	$2,843	11.02	70	39	60.53
7	ILL. CENTRAL.	$193,524.18	1,272	$152	823	61,350	2,991	66,422	$2.91	38,994,364	.0049	$3,155	10.28	84	33	74.84
8	MO. PACIFIC.	$110,076.00	550	$207	432	23,189	1,445	24,654	$4.47	19,519,167	.0051	$3,393	9.21	100	31	76.55
9	N.Y.N.H.&H.	$180,758.18	1,176	$153	2,522	35,716	1,179	40,594	$4.45	29,637,868	.0061	$1,931	7.60	69	55	63.74
10	NORTHERN PACIFIC	$184,118.53	1,430	$128	1,110	43,816	3,601	49,957	$3.68	39,810,364	.0051	$2,481	12.90	76	36	61.71
11	PENN. R.R. Co.	$998,174.71	3,437	$285	2,119	145,917	3,679	151,033	$6.60	94,960,654	.0100	$2,840	10.28	76	28	68.70
12	SOUTHERN RY.	$207,043.93	1,176	$176	1,037	49,388	2,047	52,611	$3.93	40,668,013	.0050	$2,454	9.24	94	35	67.43
	TOTAL	$3,652,479.03	19,202					752,218								
	AVERAGES			$190					$4.85			$2,702	9.84			
	PER CENT SANTA FE ABOVE AVERAGE			56%					78%			41%	33%			

mile run on twelve of the more prominent lines in the territory bounded by Chicago on the east, Pacific Ocean on the west, Canada on the north, and Mexico on the south, the Santa Fe occupying a somewhat middle ground position.

It will be noted that, notwithstanding the high cost of the Southern Pacific, which is, more strictly speaking, a mountain road, and entirely in the zone of maximum prices for both labor and material, the average cost per engine per year on the Santa Fe is 21 per cent. above the average of all twelve lines, and 25 per cent. above on a basis of cost per mile run.

Section Two.—The second portion of the table treats with one item of expense not heretofore given much, if any, prominence in the analysis of costs, and that is the item of "superintendence maintenance of equipment," or, in the more common language of the street, what it costs to *boss the job*.

This analysis, or comparison, was really invited by the very extravagant claims of great saving made on the Santa Fe, in which mention was made of the slightly increased cost of supervision necessary in order to enjoy the great economy resulting therefrom. The figures present quite an interesting study, particularly when considered in connection with the companion section No. 1, and the preceding table on page 19, of Sante Fe statistics.

The cost of supervision, or superintendence, is first given in full for twelve lines representative of the leading railways of the United States, and from a geographical standpoint, quite evenly distributed.

The first ratio of cost is based on the number of engines, while the second, which is the *better* of the two, is based on the total number of engines and all kinds of cars.

By the first comparison it will be noted that the Santa Fe is 56 per cent. above an average of all lines, and by the second 78 per cent. above an average.

Next, the locomotive mileage, average cost per engine per year, and per mile run, is given, with averages of all, and by this comparison it will be observed that the Santa Fe is 41 per cent. above an average cost per year, and 33 per cent. above an average cost in cents per mile run.

From the foregoing statistics, it would appear that the figures generally given out with reference to the millions of dollars saved

to the Santa Fe Company by "scientific management" will not "*bear analysis*"; that the experiment has been a *most expensive one*, that they are not doing as well as a majority of other lines operating in the same, or similar territory, and are far *below* the average of efficiency attained by many prominent trunk lines of the country, or of the railways of the United States.

COMPARISON WITH THE UNITED STATES.

The average cost for maintenance locomotives, freight cars and passenger cars in the United States, and of the Santa Fe, was as follows:

Items	Average cost in U. S.	Cost on Santa Fe and amount above U. S.	
		Cost on Santa Fe	Total excess am't on each item
Locomotives	2,368	$3,832	$2,819,664.00
Freight Cars	77	108	1,774,454.51
Passenger Cars	737	1,249	738,375.00
Cost on Santa Fe in excess of U. S. average			$5,332,493.51

From the foregoing it certainly should be clear to everyone that the Santa Fe Road, which is now, and has been for six years, under a heavy expense maintaining "scientific management" plan, has a maintenance of equipment cost of over $5,000,000 per year above an average of the United States, and far in excess of most all other lines similarly situated, except in the matter of this special feature of expense. It is, therefore, unnecessary to enter into details with respect to the possibility of maintaining locomotives on 6 cents per mile and freight cars on $35 per year, and passenger cars on a corresponding amount, as the proposition will not justify consideration.

The unprejudiced railway man, who is guided by knowledge, born of experience in the solution of such problems, is forced to the conclusion, that, notwithstanding the unqualified support given this plan by the operating vice-president in charge, over a period of six years or more on the Santa Fe, it does not, on analysis, present results at any time in this period that would commend it for general adoption in railway operation.

EXAMPLES OF EFFICIENCY IN THE REORGANIZATION AND MANAGEMENT OF THE MECHANICAL DEPARTMENT OF A RAILWAY.

Two examples of most excellent results in the reorganization of the mechanical department of a railway, embracing as it did, maximum efficiency at a minimum of cost, might serve to show the possibilities under conditions that, while manifestly *bad,* had become so under oppositely different systems of management, each having gone through with, and partially *recovered from,* the effects of a shopmen's strike, and had, for some time, been enjoying the economies usually following a successful issue of that kind, so that such comparisons as may be made, or reductions shown in cost, or improvement effected, are measured from a point below average conditions.

Example A.—On this line the physical condition of the power and rolling stock was very bad, while the organization was demoralized and, therefore, inefficient. The management was thoroughly aroused at conditions and was prepared to authorize additional funds to meet the anticipated increased expenditures involved.

After making a careful study of the situation, however, it was decided to first obtain maximum efficiency from present facilities before incurring heavy expenditures for new locomotives, freight cars, passenger cars, shops, shop tools and additional force.

The engineers, firemen, shop forces, officers, and clerks were all in a highly nervous state and naturally skeptical of the meaning of every move, which rendered it doubly necessary that no mistakes be made. The cry from almost every direction was for increased facilities, either machinery, tools, men, or all three. The shop output was low in quantity and not of the best quality, and immediate action was necessary.

Instead of theorizing for weeks or months, and then another similar period in experimenting on theories, a well-defined plan was in working order and giving results inside of thirty days.

Many machines that were thought obsolete, it was found only needed slight repairs and intelligent operation, thus saving the price of new ones, and indirectly increasing the output of others, and in many cases a substantial increase in the compensation of the operators.

The entire department, including enginemen, became converted to the new order of things at once, and combined to attain 100 per cent. efficiency in a thoroughly practical manner, and the results, which were in some instances realized inside of thirty days, were substantially as follows:

	Per cent.
Increased shop output, number of engines	56
Reduced shop cost of engines	19
Reduced cost repairs per mile	16
Reduced cost lubrication per mile	29
Increased number passenger cars through shops	38
Decreased cost per car	20
Decreased cost per car for lubrication	24
Increased number of freight cars repaired	29
Decreased cost per car	14
Decreased cost per car for lubrication	16
Increased cost of supervision, clerks, etc.	NONE

The above results were obtained, much to the surprise of those in charge, at a cost less than the corresponding preceding period of over 3 per cent., while it had been conservatively estimated that an increase of 15 or 20 per cent. in pay rolls alone would be necessary to overcome the general poor condition of equipment.

Example B.—The conditions on the second line in question, while not generally as bad as on the first mentioned line, were worse in some particular respects, in that the organization had been on an entirely different basis; therefore, the remedial measures to be applied were, of necessity, fitted to suit the case and somewhat different than in the first mentioned case.

The financial conditions had been such for years that the power, rolling stock and shops had been sadly neglected, and fallen into a state of repair that prevented much of it from being operated at all, something like 12 to 14 per cent. of the freight cars being parked out in bad order, account no funds to make repairs. The shop forces, while not decidedly bad, were far from good. This, however, was largely due to the form of organization rather than the men in direct charge.

Confronted with a condition calling for the expenditure of large additional sums of money, heavy reductions were at once put into effect, the total amount of reduction made in 60 days

press and current magazines, much of it *highly colored*, but most all detrimental or openly hostile to corporate interests.

One of these articles appeared in *Hampton's* for March, pages 346 and 356, from the pen of a very forceful writer. The tenor of the entire article is such as to poison the public mind against corporations regardless of the facts in the case.

Among the many very extraordinary statements there are a few that have special reference to the subject matter under consideration, and to which I shall refer.

"TWO MILLIONS A YEAR WASTED ON OIL."

On page 347 appears the following quotation:

"Mr. Brandeis estimates that, in the comparatively small item of lubricating oil, our railroads waste two million dollars a year because Wall Street influences them to buy their oil from the 'Standard Oil' interests, in spite of the fact that independent refiners would gladly sell them an equally good article for less money. Such independent concerns have learned long since that even the most favorable bids against the firmly entrenched interests will not be considered.

"Of course, two millions is nothing in the huge annual budget of our railroads—it is like the loose change that a clerk spends on picture shows—yet a hundred thousand weary commuters must deny themselves twenty dollars each in order to raise two million dollars, twenty dollars each, that they might keep if grim magnates did not need the money."

The foregoing is, to say the least, a very broad and sweeping statement, and may be summed up, as follows:

First: That the railways of the United States stand charged with wasting two million dollars per year on the single item of "lubricating oil," due to Wall Street or Standard Oil influence.

Second: That the burden of this waste by the railroads of the United States comes on *"one hundred thousand weary commuters"* who must deny themselves twenty dollars each, per year, that they might keep "if grim magnates did not need the money."

As there can be *no possible* connection between an item of waste on the railways of the United States and a fixed number of classified passengers, the statement at once automatically receives the stamp of unreliability in character and hostility of purpose.

Let us review the facts in the case.

RAILWAY PASSENGERS CARRIED—CLASSIFIED (1909).

Total number passengers carried (I. C. C. reports)	891,472,425
Total number of passengers carried one mile	29,109,322,589
Passenger revenue	$563,609,342
Number of commuters (railway companies' statistics)	188,359,788
Revenue from commuters, estimated on basis of each passenger riding 10 miles at six-tenths cent per mile, or six cents per trip	$11,301,587
Per cent. of passenger revenue from commuters, estimated	22

Taking the average number of commuters handled per day, based on the figures for 1908, which are low, if each one pays $20 per year too much fare, the total excess from this source would be as follows:

Average number of commuters per day	606,554
Amount per year at $20 each	$12,131,080

which, it will be noted, is more than the entire estimated income from commuter travel for the entire year.

The average rate per mile paid by all passengers on our railways is slightly above two cents, while that paid by the commuters is considerably less than one cent per mile (to be more exact, about six-tenths of a cent), from all of which it would appear that commuters are now enjoying a lower rate than other passengers, and that there is no intelligent application possible of the number of commuters, or the sum of money mentioned, to the statistics of passengers carried, or earnings therefrom.

From the foregoing facts, with respect to passenger traffic, it is clear that the author of the article in question was either uninformed on this matter, or purposely garbled the figures with mischievous intent.

We may now go further and see about the alleged waste of two millions per year in the item of oil.

In the early history of our railways most all supplies were bought at a flat rate per unit of quantity, and in the items of oil, tallow, and waste the quantities used depended largely, if not wholly, on the judgment or disposition of those who used it, *i.e.*, enginemen, trainmen, and carmen.

The governing factor in car lubrication was the size or cubic

capacity of the journal box, for both car- and trainmen were strong advocates of "Gospel measure," full and running over. The same was true with respect to locomotive lubrication except that the engineer was privileged to observe the *Biblical injunction* at various and divers places on each trip, while the car journals were, as a rule, not given an oil bath at such frequent intervals.

Along many tracks where cars and engines were regularly oiled, the oil thus wasted actually stood in pools or puddles, and if an engine's drivers slipped in starting, one would need an umbrella, if standing near, as a protection from the falling oil.

Some excuse for what now appears to have been a great waste at that time, in quantity at least, was the fact that the lubricating oil was largely of a very cheap grade.

Some 30 years ago (1880), when there were in round numbers about 100,000 miles of railway in the United States, and the construction of new lines and other industrial development of the country in general were on a gigantic scale, those in charge of the work, especially railway construction and operation, could not give close attention to details. Certain others saw the need of improvement, and set to work in a systematic, business-like manner to bring it about, and to these pioneers properly belongs the title of *efficiency engineer* in its broadest sense, for the great financial benefits that have accrued to railway companies from the economies in operation which they made possible.

In the matter of lubrication, a superior quality of oil was produced, but like good clothing, food, fine horses, or other high-class commodities, it cost more than an inferior or poor grade; therefore, the railways would not at first consider its use, for the reason they did not see how any less quantity would serve their purpose, and at the increased price per gallon this would result in a big increase in cost of lubrication.

To meet this condition, the oil company offered to make the railroads safe against loss by a guarantee, on a mileage basis, staking their reputation and the difference in price, between a high-grade compounded oil and the cheap product then in use, against the results they felt sure could be obtained. The success of the plan proved the superiority of the good oil, and from this beginning the use of these oils was gradually adopted by most all lines, for in most every case there were the following good reasons for making the change:

First: A guaranteed reduction of 10 per cent. on existing costs per thousand-mile run.

Second: A guaranteed cost per thousand-mile run in future on all service.

Third: Responsibility for fluctuations in item of cost of lubrication on a mileage basis, transferred from railroad to, and assumed by, the oil company.

All of which are excellent business reasons why any efficient railway manager would secure the higher grade and more efficient oils at a *higher initial* cost per gallon, but with a much *less net cost* for the *same unit* of service.

The result is, that at present, and for some years past, about 98 per cent. of the mileage and equipment is lubricated with the oils furnished by one company on the guaranteed mileage basis plan above mentioned, and in most every instance the change was made by virtue of the displaced oil company not being able to meet the 10 per cent. reduction offered, thereby losing out on a fair, square, competitive business proposition.

ECONOMIES EFFECTED BY OIL COMPANY.

When the oil company that now stands charged with coercing the railways into wasting two million dollars a year, through the purchase of their goods, first secured the business, it was, as previously stated, on a guaranteed reduction in cost per 1000-mile run of 10 per cent., and protection against increased costs in future.

Since these oil contracts have been generally accepted by our railways, the trend of most all prices or cost for material and labor has been upward, except on two items, one of which the railways purchase and the other they manufacture and sell, namely: lubrication and transportation.

The cost of labor and material (except oil) has advanced during the past twenty years in a most remarkable degree, the various estimates ranging from 20 to as high as 100 per cent., and it is fair to assume that if the guaranteed mileage feature of lubricating railway equipment had not been introduced and maintained (sometimes at great loss to the oil company) the cost of lubrication to engines and cars would have increased, both in proportion to their *increased size* and the general advanced cost of other materials and labor used in railway operation.

As locomotives have been more than doubled in size or capacity, and in many other ways require additional lubrication, and both passenger and freight cars have likewise increased in size, it is thought that a conservative estimate of the increased cost for lubrication, if left on the old basis of 20 years ago, would at present be about as follows:

Locomotives, per 1000 miles	$6.00
Passenger cars per 1000 miles	.60
Freight cars per 1000 miles	.30

On the above basis the cost for lubrication to our railways would have, in all probability (in 1909), been as follows:

Locomotive miles,	1,529,454,537	@ $6.00	per 1000,	$9,176,727
Passenger car miles,	2,746,510,733	@ .60	per 1000,	1,647,906
Freight car miles,	17,169,413,224	@ .30	per 1000,	5,150,824
Total				$15,975,457

As a matter of fact, however, the oil company has gradually reduced the general average cost of lubrication, per 1000 miles, on both cars and engines, thus effecting economies that have saved, and are at the present time saving, the railroads millions of dollars.

The exact average cost of lubrication per 1000-mile run on all railways is not known, but from an average of quite a number of the leading lines the cost may, for comparative purposes, be estimated as folows:

Locomotive miles,	1,529,454,537	@ $2.50	per 1000,	$3,823,636
Passenger car miles,	2,746,510,733	@ .12	per 1000,	329,581
Freight car miles,	17,169,413,224	@ .05	per 1000,	858,470
Total				$5,011,687

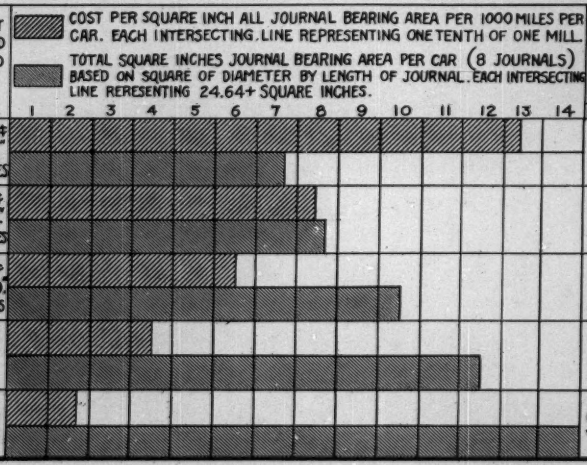
From which we secure the following figures:

Estimated present cost of lubricating equipment on railways, if the oil company had not only *prevented* an increase, but systematically reduced cost for the past 20 years	$15,975,457
Estimated present cost	5,011,687
Present saving to the railroads on the item of oil	$10,963,770

I will next invite attention to a graphic chart (Table G), showing the *increased* size or area of freight car journal bearings,

TABLE G.

GRAPHIC CHART SHOWING ECONOMY IN FREIGHT CAR LUBRICATION ON MANY LEADING RAILWAYS, RESULTING FROM REDUCED COST PER 1000 MILES RUN, WHILE THE EQUIPMENT HAS, IN MANY CASES, MORE THAN DOUBLED IN SIZE. SIMILAR, AND IN SOME INSTANCES, GREATER ECONOMIES HAVE BEEN EFFECTED IN LOCOMOTIVE AND PASSENGER CAR LUBRICATION


COST PER SQUARE INCH ALL JOURNAL BEARING AREA PER 1000 MILES PER CAR. EACH INTERSECTING LINE REPRESENTING ONE TENTH OF ONE MILL.
TOTAL SQUARE INCHES JOURNAL BEARING AREA PER CAR (8 JOURNALS) BASED ON SQUARE OF DIAMETER BY LENGTH OF JOURNAL. EACH INTERSECTING LINE REPRESENTING 24.64+ SQUARE INCHES.
1 2 3 4 5 6 7 8 9 10 11 12 13 14

PER 100	ESTIMATED AVERAGE COST PER 1000 CAR MILES AND SIZE OF JOURNALS 1890 TO 1910 INCLUSIVE FREIGHT SERVICE	NUMBER SQUARE INCHES JOURNAL BEARING AREA LUBRICATED ONE THOUSAND MILES FOR ONE CENT AND INCREASE OVER 1890 IN PER CENT		PER CENT DECREASE COST OF SERVICE OVER 1890
		NO. INCHES	INCREASE	
1890	COST PER 1000 MILES 20¢ SIZE OF JOURNALS 3¾" X 7" AREA BEARINGS. 165 SQ. INCHES	8.25		
1895	COST PER 1000 MILES 18¢ SIZE OF JOURNALS 4¼" X 8" AREA BEARINGS. 213 SQ. INCHES	11.83	43.39%	10%
1900	COST PER 1000 MILES 14¢ SIZE OF JOURNALS 4½" & 5" X 9" AVERAGE AREA. 235 SQ. INCHES	15.33	83.55%	30%
1905	COST PER 1000 MILES 10¢ SIZE OF JOURNALS 5" X 9" AREA 282 SQ. INCHES	28.20	241.81%	100%
1910	COST PER 1000 MILES 6¢ SIZE OF JOURNALS 5½" X 10" AREA 345 SQ. INCHES.	57.50	584.84%	233%

and the decreased cost per 1000 miles, and per square inch of area, for the past 20 years.

The chart is, on a little study, replete with data in confirmation of the foregoing statements and figures, all of which are alike applicable to locomotives, freight and passenger cars.

Yet, in the face of these facts that are within reach of any one *searching for the truth* in the matter, the oil company stands charged with practically forcing the railways to waste two million dollars per year.

In addition to the economy to railways on the item of oil alone, there were many other economies enjoyed as a result of their oil contracts, as the oil company furnishes experts, free of charge, to supervise the economical use of the oils, and in their co-operation with mechanical and operating officers many improvements in the design and repairs of motive power, handling of equipment, stores and supplies have been accomplished, this item amounting in the aggregate, doubtless, to many times the sum of two million dollars per year which the oil company stands accused of causing to be wasted.

It may therefore truthfully be said that regardless of what mistakes may have been made by the Standard Oil Company (and none are pointed out by its critic), the Galena Signal Oil Company, which supplies lubricating oils for about 98 per cent. of the railway mileage, has, as a result of this analysis, been relieved from the general charge of causing a considerable waste, and credited with effecting much economy that actually adds to the cash balance in the treasury. And to such companies, their founders and leaders should be given the credit they justly deserve, instead of being held up as public enemies.

There are to-day in this great Commonwealth of Pennsylvania three industrial concerns in particular that have contributed much to the cause of efficiency engineering. I refer to

THE BALDWIN LOCOMOTIVE WORKS
THE WESTINGHOUSE AIR BRAKE COMPANY
THE GALENA SIGNAL OIL COMPANY

and to the names of the men who founded and built up these splendid companies may properly be added, such as James J. Hill, Andrew Carnegie, Richard T. Crane, Thomas W. Scott, George M. Pullman, Reuben Wells, and many others.

The Westinghouse Company, in the development of the air-brake, has contributed more than any other one company toward making it possible for our railways to handle in one year the following volume of business:

Tons freight carried one mile.....	29,109,322,589
Passengers carried one mile.....	218,802,986,929
With a total net revenue from operation of.....	$2,418,677,538

For, without the improved air-brake, making it possible for the engineer to stop high-speed passenger and fast freight trains, there would be no *eighteen-hour* passenger trains, or *three-day* freight trains between New York and Chicago. Fresh vegetables and tropical fruits gathered in Florida on Thursday could not be served on your tables in Philadelphia and New York on Sunday, and the two hundred million commuters who annually come to, and return from, their places of business at speeds of from 40 to 60 miles per hour, in trains, many of them less than 10 minutes apart, would either have to give up their suburban homes and live in flats, or devote probably one to two hours per day more in travelling to and from their homes.

While it would be extremely difficult to estimate in hundreds of thousands, or even millions of dollars, the benefits that yearly accrue to our railways through the agency of the modern air-brake, it may safely be said that with all our other highly developed modern railway equipment, that if we were dependent, for one day, on the brakes of 20 years ago, the business of the country would be practically paralyzed, and the loss of both life and property very great.

LUBRICATION—CONCLUSION.

In the matter of lubrication, the Galena Signal Oil Company has, by its efficiency engineering system of basing net costs on guaranteed service rendered, disregarding the purchase price per gallon of its high grade oils, succeeded, as previously stated, in securing about 98 per cent. of the business of our railways. And strange as it may seem, it is nevertheless true, that, although motive power and cars have, during the past twenty years, in most instances just about doubled in size or capacity, the oil company has constantly reduced the cost of lubrication per 1000-mile run, and has therefore effected a double saving—one on the reduced

cost per 1000-mile run by cars and engines, and the other in providing lubrication for, and accepting as one unit, the thousands of new engines and cars that are twice the size of, and equal to two of, the type and size built some years ago.

From a review of the foregoing figures and facts, it should be clear to any unbiased mind that the actual saving to the railways, in money, on the single item of lubricating oil, based on cost of service rendered, is not less than an average of $5,000,000 per year for the past twenty years, and the additional saving, due to the increased size or capacity of engines and cars, together with the unestimated economies in various other items of a collateral character, resulting from the "*efficiency engineering system*" so successfully practised by the Galena Signal Oil Company for the past twenty years, that it would be safely within the bounds of conservatism to place the actual amount saved at not less than about $100,000,000 and that the present saving may be estimated at about $10,000,000 per year, which not only justifies placing this company among those engaged in effecting economy in railway operation, but discredits the statement that the oil company either uses coercion to secure contracts, overcharges for its oils $2,000,000 per year, or in any manner affects the rates of fare paid by commuters.

RAILROADS RUN BY "RULE OF THUMB."

On page 355, *Hampton's* for March, the same author, previously quoted, makes the following statement:

> "At present, with our railroad business conducted more or less by 'rule of thumb,' there are wide margins where stealing is possible, since *no one* can be *sure* where waste begins and stealing ends. *No one* knows exactly how much should be spent for the repairs of a freight car. It may be $30, $40, $50, $60 or $70."

Anticipating the possibility of the general application of this charge by the reading public in its literal sense, it might not be amiss to first state that the following employees of the operating departments of our railways work under, and conform to, the standard rules adopted by the American Railway Association. They also have, with few exceptions, contracts made through their organizations, and in one or both of these their movements, rates of compensation, and duties are minutely outlined.

Connected with train movement there are:

Engineers	57,077
Firemen	63,349
Conductors	43,608
Other trainmen	114,760
Section foremen	41,859
Other trackmen	320,762
Telegraph operators and dispatchers	39,115
Total	680,530

Shopmen—Maintenance of Equipment.—Of the shopmen whose duties and rates of pay are not all prescribed in the book of rules, there are the following:

Machinists	48,237
Carpenters	60,867
Other shopmen	195,110
Total	304,214

Of the 304,214 shopmen a large majority of them are working under contracts that clearly define their duties and pay for the various classes of work, while quite a large number of the principal lines operate their main repair shops on a most thoroughly detailed piecework schedule, some schedules covering as many as 3000 or more items, with costs ranging from one-quarter of 1 cent, or two and a half mills, to upward of $10, or a range of over 43,000 per cent., every item or operation in locomotive and car work being covered so completely as to brand, at once, the "rule of thumb" statement as a misstatement of facts, there being few, if any, corporations, outside of railroads, that have gone as deeply, thoroughly and scientifically into the minute details of unit costs and accuracy of operations as the railways have.

SYSTEMATIZED COST OF MAINTAINING EQUIPMENT.

The extent to which actual costs of the thousand of different operations in the maintenance of equipment have been applied on most of our leading railways during the past ten or fifteen years could not well be covered, save in a special paper on that subject. It would appear sufficient answer to those who assert

no such plan is in existence to simply say that such plan has been for years in successful operation, and is now in daily use on about *sixty thousand miles* of railway in the repairs of probably more than 800,000 freight cars, aside from locomotives and passenger car work.

EXAMPLE OF SYSTEMATIZED COSTS.

On one prominent trunk line the maintenance of equipment is conducted, so far as practicable, under a most thoroughly efficient system of compensation, based on a schedule of prices for the various operations in locomotive and car work, varying in price from one-quarter of one cent (or 2½ mills) to as much as $10.80 on two different items, or a range of 43,200 per cent. in prices. Every possible operation in the repairs of locomotives or cars, from driving a small nail in a roof to changing the driving wheels of a locomotive, is fully covered, and in car work the number of items and range of prices are equally as complete, so that every known item, both in the machine or smith shop, mill or fitting room, that can be, has a scheduled price which yields a wage in proportion to the operator's ability, the minimum day's pay being the standard rate for the class of workman.

As an example of the very thorough and systematic manner in which maintenance of equipment has been handled for years on many of our trunk lines, the price schedules of the line in question, with certain sample pages, have been photographed. Your attention is invited to the following items:

First: Schedules of prices in book form, seven copies.

Second: Sample page from schedule of car work prices showing a range of rates from one-quarter of one cent (or 2½ mills) to $10.80, or 43,200 per cent.

Third: Sample page from schedule of locomotive prices ranging from 5 cents to $9.70, or 19,300 per cent.

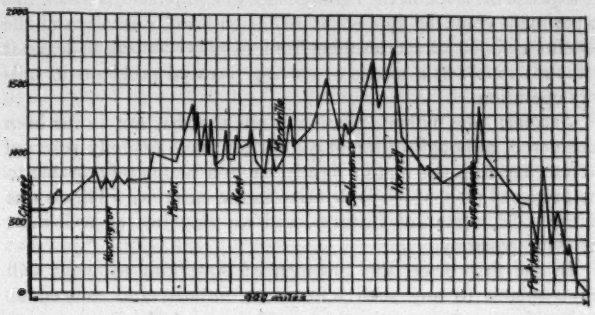
These schedules embrace more than one hundred and seven thousand items, or operations, on cars and locomotives, and have been gradually extended to all work at points where practical, until over 90 per cent. of the work at many places is being handled in a manner satisfactory both to the workman and the company.

The earnings of the workman clearly reflect the improved

shop conditions under which the company's power and rolling stock have been materially improved, and at a much reduced cost from the flat day work plan.

This line is one of the heavy freight carriers between Chicago and New York City, and although operated under adverse conditions, the splendid service rendered, together with the improved physical condition of the entire property, reflects the very able management and efficiency of departmental heads, who have made possible such good results.

PLATE J.



A profile (Plate J) of the line will more clearly indicate its physical characteristics.

CONCLUSION.

Having reviewed from different angles the most important phases of the question under consideration, weighing carefully, not only the numerous and rather extravagant claims made for "scientific management," but also the statistics of the only line that has for years employed this system, or plan, the only verdict possible from the evidence is most emphatically against the adoption of any such plan or scheme as contemplated by the very able attorney for the shippers in the recent rate case, and the various writers who have contributed to the support of the scheme to save one million dollars per day to the railroads, by means that it may safely be assumed, if adopted, would embrace the following:

First: The employment of a large additional force of expensive but not productive men, who, as a rule, are unfamiliar with the practical operation of a railway, and consequently not in sympathy with methods essential to *efficient management,* which is paramount to any of the multiplicity of shop operations that may have been reduced to a highly scientific basis, but all of which, if combined, would only aggregate a *small* portion of the cost of maintenance of equipment, the total of which is only 22 per cent. of the cost of operating our railways. So that, aside from the human equation, the quantity of the work, or percentage of expense involved in the maintenance of equipment to which this experiment could be applied, is so insignificantly small, and the benefits claimed to accrue therefrom so uncertain, as to leave it without support as a means of solving financial problems in railway operation.

Second: The human equation is one that has not so far been considered, although different authorities have casually referred thereto, treating the matter lightly, or in a manner favorable to the proposed plan which is delusive in the extreme. This is one of the most important features, and we may just as well meet the issue squarely.

In the first place, the shopmen of American railways will never submit to any such scheme as outlined and defined as "scientific management," neither will mechanical officers accept it without protest, and its introduction would, if made simultaneously on all lines, precipitate an industrial struggle, the toll from which would be measured in human lives and millions of dollars.

The ratio or percentage of men who would come up to all requirements and retain employment, as compared to the number that would be cast aside, either through failure to enter or the result of working under the new and more exacting conditions, would be so small that the working forces could not, in all probability, be maintained. But, even if the requisite number were available, it is beyond range of the remotest probabilities to expect 243,347 American mechanics and shopmen to work under such a plan, while more than one million and one-quarter of their fellow-citizens and employees were enjoying much more favorable conditions in the same line of endeavor, most conspicuous among whom would be the newly added employees.

Third: No one is more familiar with the difficulties encountered in railway operations due to the attitude of organized labor than myself, and while it is a fact that many railway officers and foremen would, if not hampered by contractual conditions made by the management with the unions, treat many of the men they personally know more liberally than they do now, yet, at the same time, there is no doubt but their present compensation and working conditions are largely, if not wholly, due to their organization, which if eliminated would probably result in the money powers, or corporate interests (that are wholly impersonal), reducing compensation and changing working conditions when they are confronted with financial difficulties, therefore, the question of the *application of scientific management to the practical operation of railways* resolves itself into one of "making the best use of facilities," and, in doing this, the man best equipped to handle men is without question the man most needed by the railroads to increase the efficiency of their facilities, and thereby contribute to the production of transportation at the lowest possible cost, that the net income from operation may, if possible, be increased.

Fourth: The underlying principles of "*intelligent human endeavor*" were clearly enunciated by Solomon, King of Israel, over two thousand years ago when he exhorted the inefficient and lazy as follows: "Go to the ant, thou sluggard: consider her ways and be wise." And at various times in the world's history this same principle has become conspicuous either in its application in a broad sense, or its absence.

Kings, queens, statesmen, soldiers, sailors, engineers, lawyers, railroad men and farmers have been elevated to the highest pinnacle of fame or relegated to obscurity by adoption or rejection of this principle, and to hold there is some new discovery in "scientific management" erroneously implies that lines not employing these methods are unscientific, inefficient, or behind the times, while as a matter of fact the principles of efficiency have been constantly practised since the earliest history of man, and have been in railway operation since the construction of the first line in the world, and there is no place in the civilized world today where "nature's forces are applied so efficiently to the use of man" in the production of railway transportation as on American railways, and if the very able writers on, and advocates of, the scientific management plan, who have so unsparingly criti-

cised the present management of our railways, would employ some of their time and energy in an effort to bring about a more friendly feeling toward corporate interests, especially railways, from our courts, legislatures and the public in general, much more could be accomplished toward economy and efficiency in operation than by holding them up to the public eye as examples of extravagance or inefficiency.

The writer has received much valuable information from railway officers and other sources of recognized authority, for which grateful acknowledgment is hereby made.

DISCUSSION.

MR. F. H. CLARK, General Superintendent Motive Power, Baltimore and Ohio Railroad: *Mr. Chairman and Gentlemen:* I am sorry that I have not had an opportunity to read Mr. Symons's paper and that I did not arrive until after the reading of the paper had begun. I feel that under the circumstances I am not very well prepared to open the discussion, or even to discuss his paper intelligently.

It seems to me that most writers on the subject of "Efficiency" overlook or ignore the fact that the railroads of the country are, and have been for a good many years, giving a good deal of attention to this question of efficiency, not only in shop operations, but in the matter of fuel train load and other transportation costs. Had nothing of the sort been accomplished by the railroads in the past twenty years, they would certainly have been unable to meet the reductions in rates that have been brought about, in spite of increases in rates of pay and costs of material used, and at the same time improve their service.

I think it is quite possible, also, that these writers fail to appreciate the difficulty of effecting important reductions in the cost of railroad operations as compared with manufacturing operations, because of the fact that the former are widely scattered and a great deal of money in the aggregate is spent at points where facilities are necessarily poor and where it would not be economically possible to provide facilities for doing the work at as low a cost as it could and should be done at larger points where more work is done.

Mr. Symons's paper refers principally to shop operations and the possibility of effecting further economies in that direction. He has pointed out the fact that in a good many instances it seems impossible to bring about further economies. The subject had the careful consideration of the railroad companies, and as conditions change and new and improved methods are devised the railroads are generally ready to adopt them.

MR. S. M. VAUCLAIN, Vice-President, Baldwin Locomotive Works: It has been some time since I was engaged in active railroad work, but I am still engaged in building locomotives for those who are proficient in railroad management, wherewith to carry on their business.

The term "Scientific Management" is, to my mind, just what Mr. Symons has described it—somewhat of a misnomer. It might be called "economical" management with greater accuracy, because economical management has been in existence ever since I was a boy, and probably before that. We have read a great deal in the newspapers lately as to how managers should manage their property to derive economy, telling us just how to do it and how many millions of dollars could be saved by doing it just that way. Now, I do not know of any persons more anxious to save those millions than are the railroad managers themselves.

The first economical railroad management I was interested in was in 1875. The master mechanic of one of our large railroad systems happened to have been an inspector of locomotives at the Baldwin Locomotive Works, and when he returned home immediately set the wheels in motion and turned his attention to study efficiency and economy in the repair of our locomotives, and the same institution established at that time has been continued and perfected, and I doubt if to-day any other railroad in the United States has a more perfect system of handling its locomotives than has this same railroad. If this is true—and being familiar with it from the time it was started I know it to be true—it proves that there has been, and still is, some economic management by railroad officials.

When Mr. Symons calls attention to the scientific management now in force on the Santa Fe Railroad, and of which much has been said pro and con—it having been the only road so far

that has striven by such methods to reduce their costs—we must consider that many of their shops are located where it is difficult to obtain men, and that the cost of doing their work is not only influenced by material and prices, but by the enormous size to which their locomotives has increased. The size of the locomotives on the Santa Fe Road in 1910 was between 50 and 75 per cent. greater than it was in 1900, if locomotives are to be measured by their tractive power. Therefore, what is true of that road will also be true of other roads, and it would take a long time to analyze the figures and make a thorough study of them as presented in these tables. Mr. Symons has no doubt made a thorough study of them, and so is not to be thought guilty of eliminating facts before this meeting, for he certainly will have to stand for them hereafter. But I call your attention to the fact that locomotives have increased greatly in size during the last decade, and the possibility is that they will increase still more, and the probability is that railroad managements will continue to be called down because their expenses are increasing per engine mile. Also, each locomotive is being worked up to a greater efficiency, or rather to a greater percentage of its maximum efficiency, by the railroads. All the devices of their mechanical engineers, all the devices they can secure, are being tried in order to promote the efficiency of the locomotive, and in addition on many railroads large expenses are being incurred in modifying and altering the type of locomotives, all of which, or much of which, may be charged to their maintenance cost.

Another item is the question of speed. The feeling is that we all must go faster. Ten years ago none of us would have thought of flying, but the idea of our getting up in the morning now without giving a thought to the flying-machine is ridiculous; everybody does so, and we believe that these things are going to be instruments of common use. The flying-machine to-day is one of the most discussed things of modern times; anything with an element of danger in it is sure to draw a crowd. We must now run our freight through from the West to Philadelphia or to the seaboard in a specified number of hours, otherwise our freight is passed over to another road that will maintain its power to such a point as will enable it to give satisfactory service under guaranteed conditions.

Having been an employer of labor all my life, I naturally

feel that every employer should start out to save money; most employers save it from the wages paid their men. Materials bought in the market are standard, and if we economize we must do so in our labor by the scientific handling of that labor. If all laboring men were precisely the same, a system could probably be established by which we might handle all our workmen like so many machines, but they are not all precisely the same. Go into a stocking factory and you will find, say, twenty-five machines operated by one woman, all attending to business and producing with a maximum efficiency. In a machine shop, however, your human machines are not all of maximum efficiency; they are of variable efficiency, and you cannot change it. You cannot weed out and give your competitor all the poor ones, because he very wisely won't have them. You must be content with a proportion of the good and of the bad and of the indifferent. There is nothing so plentiful as poor labor, and that you do not want at all. If you want to save money from labor on a railroad you cannot save it by reducing the President's salary; you cannot save it from the clerks; you cannot save it from the roadmen, as they are mostly protected by unions: you have to save it in the shops. I do not care what business you are in, you must save it from the labor in your workshops. No one ever thinks he is paying too much for his materials, as prices are fixed; therefore you must save it out of your labor. Now, if my memory is correct, there are some 310,000 shopmen in railway shops throughout the country, and if we are going to save a million dollars daily from these 310,000 shopmen we would have to save about $3.30 a day from each one, which would exceed their average daily wage.

I did not expect to be called upon to speak this evening, but I happen to have with me a little memorandum that I carry around for my own protection, because when every one is attacking you for efficiency and efficient management, or inefficient management, it is very interesting to be able to go back twenty or thirty years—depending upon your own age, of course, for your ability to do so—and compare notes. It is more important that a man earn a thousand dollars a year than it is that he gets forty cents an hour for his day's work and only works two-thirds of the days in the year. He must have a living wage, and in order to do that he must have a rate of pay per hour or must have the

privilege of working a sufficient number of hours per day to insure him a living rate of wage per week upon which he can support his family. Suppose we go back to a low efficiency working standard such as we have had for a good many years and compare the pay of our workmen; for instance, in 1873 we had no electricity, no labor-saving devices, etc. In 1885 the Baldwin Locomotive Works had less than 500 horse-power in the entire works; it now takes 20,000 horse-power to run it. In 1873 the wages averaged $13.73 per week; in 1905 they were $13.93, after which there was a general reduction of 10 per cent. in all labor throughout the country, but in 1905 we ran $13.53 a week. In 1906 business was off a little and the men averaged $13.18 a week, including all holidays taken out, etc. In 1907 it was $13.37 a week, and in 1910 it averaged $13.41 a week. For the first nine months of last year it averaged $13.71 a week. To accomplish this we have spent during the last few years about four millions of dollars to increase our facilities, not by employing a thousand clerks to hold a stop-watch over every man in the place to see that he did not waste a minute, but in carefully providing these men, whose power is artificial ability, with suitable tools and lavor-saving devices for handling their work, and sufficient power to get the full capacity out of their machines, and when we had done this we gave each man a special notice that no man would be discharged for breaking his machine, and there would be no reduction in his pay. Our men during the last five weeks of this system averaged $14.14, the next week $14.12, the next $14.16, the next $14.20, and the next week $14.21, or a maximum variation from the minimum to the maximum average weekly rate of pay of only nine cents a week. This is in a shop, gentlemen, that is employing 14,000 men and whose wages are paid to them every week. The men are working faithfully. We have just gone through a little labor experience; the last trouble we had was in 1859. Most of the men who disagreed with us were led astray by labor agitators. We have eradicated the idea that was being grafted on these men as to how a shop should be managed, but the average rate of pay of the men in the shop now varies but a few cents, and the same men now earn an average of twenty-five cents a week higher, showing that by their present system of employment they are able to produce better results and earn higher wages. This rate of pay may seem low, but this rate of pay is high, because if

you will look up statistics you will find the average pay of the American mechanic is only about $600 a year. But the American workman is not employed all the time; his employer unwisely sacks him upon the least provocation in order to save his wages.

These averages I have given you, gentlemen, cover men who earn from five cents an hour as first-year apprentices to men who have applied to their occupations the highest principles of economic management and who have earned as high as 60 cents an hour. Being now a manufacturer, it is impossible for me to discuss this paper further from the railroad man's standpoint. I believe in scientific management and in economic management, but I do not believe in an espionage over human beings that grinds them down and makes them feel that they are owned body and soul by the men who control them.

G. R. HENDERSON, Mechanical Engineer, Baldwin Locomotive Works: There is little to add to what has already been said, as my thoughts have largely been anticipated by the previous speakers. I think that the railroads of this country are greatly indebted to Mr. Symons for taking up this subject, as I believe that it is the first time that the challenge has been accepted, which was the slogan of the anti-rate increase movement: "Save a million dollars a day by Scientific Management and you won't have to raise rates." The statement has gone so long uncontradicted that many people were beginning to believe that it must be true, and that careless and unscientific railroad management and operation were the order of the day; and it must be a source of satisfaction to them to have the other side presented and upheld.

From the manner in which this subject has been treated by efficiency engineers in times past, the natural impulse is to think of unloading pig-iron and repairing belts immediately the term "Scientific Management" is mentioned. It seems odd that when speaking of large accomplishments the enthusiast always begins with these insignificant illustrations, which at once rather convey the impression that there may have been a "Save at the spigot and leak at the bung" economy. Of course, the best results are obtained in all lines when they are scientifically and carefully followed up, but practical methods are equally important, and if these be lost sight of in an over-exaltation of the former the results are apt to be delusive and transient.

Coke Production in the United States. G. W. PARKER. (*Mineral Resources,* 1910.)—The amount of coke produced in the United States in 1910 was 41,708,810 short tons, valued at $99,742,701, compared with 39,315,065 tons valued at $89,965,483, in 1909. The quantity of coal used for coking in 1910 was 63,088,327 short tons. There were 578 coking establishments in existence at the end of 1910, representing 104,440 ovens. Nine establishments, representing 894 ovens, were abandoned or dismantled, and 100 establishments were idle during 1910. As to by-product ovens, 4,078 were completed and 1,200 were building in 1910. Their production amounted to 7,138,734 short tons of coke, an increase of 884,090 short tons over 1909. Of the completed ovens, 1,387 were of the Semet-Solvay type, 2,104 United Otto, 307 Rothberg, 280 Koppers, and 300 Didier ovens.

Briquetting Tests of Lignite at Pittsburgh. C. L. WRIGHT. (*Bureau of Mines Bull.,* xiv, 7.)—These briquetting tests were undertaken at the fuel testing plant at Pittsburgh to settle the following points: (1) The possibility of briquetting American lignites without the addition of binders; (2) the suitability of the German brown coal briquette presses for briquetting American lignites; (3) the percentage of moisture needed in the briquette material to give the best briquettes; (4) the approximate commercial cost of briquetting lignites; (5) the weathering qualities of briquettes as compared with raw lignites. Furthermore, the tests were to provide a supply of lignite briquettes from which to determine their value as (*a*) steam fuel under boilers, (*b*) gas producer fuel, and (*c*) domestic fuel. The results, while not conclusive, warrant a continuation of the investigations. Enough has been done to indicate that some American lignites equal German lignites in fuel value, and that probably they can be made into briquettes commercially without a binder. A sample from Texas, one from North Dakota, and one from California were made into satisfactory briquettes without a binder. It was proved that some lignites, after being slacked by exposure, could be made into briquettes without using any binder, notwithstanding a general opinion that this could not be done. Cohesion and weathering tests showed that good briquettes endured handling and resisted weathering much better than the lignite from which they were produced.

Disintegration of Nickel and Aluminum Alloy. ANON. (*Brass World,* vii, 10, 348.)—An alloy of equal parts of nickel and aluminum will disintegrate spontaneously. An ingot of this alloy disintegrates to a powder in a few months, simply exposed to air. This disintegration is not due to oxidation, for the powder has the same chemical composition as the ingot.

POYNTING'S THEOREM AND THE EQUATIONS OF ELECTROMAGNETIC ACTION.

BY

W. S. FRANKLIN,

Professor of Physics, Lehigh University.

THE mathematical theory of the electromagnetic field is usually developed in terms of electric and magnetic intensities in space, and the equations are almost unintelligible to the electrical engineer, who is in the habit of expressing everything in terms of voltage and current. Everyone who understands electromagnetic theory, however, knows that *voltage* is a generalized parameter which completely represents the electric field distribution, and that *current* is a generalized parameter which completely represents the magnetic field distribution when the form of the circuit is given. Therefore it is possible, for any given shape of circuit, so to transform [1] the electromagnetic equations that voltage and current may replace electric and magnetic field intensities. When this is done the unfamiliar electromagnetic equations reduce to the extremely simple and universally familiar voltage and current equations of the electrical engineer. It is the object of this paper to reduce the usual expression of Poynting's Theorem and the usual equations of electromagnetic wave motion to familiar expressions involving voltage and current. This reduction is rather difficult if carried out strictly and in detail, and therefore a general statement of the nature of the transformations is given instead of the algebraic transformations themselves.

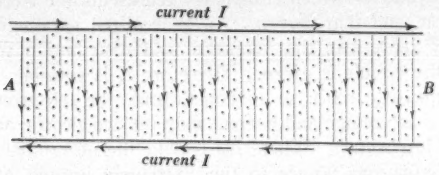
POYNTING'S THEOREM.

The rate at which energy streams past a point on a transmission line is equal to EI, where E is the voltage across the line at the point and I is the line current at the point (outgoing current in one wire and returning current in the other wire).

[1] It is always easiest to think of an algebraic transformation as a new type of space measurement, as explained below.

To say that this is Poynting's Theorem is more or less ridiculous, because this relation was known before Poynting's Theorem was ever thought of, but it is Poynting's Theorem all the same, as can be shown most easily in the case of a "transmission line" which consists of two broad, flat parallel metal ribbons. In this case the electric field is uniform, as represented by the fine vertical lines in Fig. 1, and the magnetic field is uniform (the dots in Fig. 1 represent an end view of the lines of force of the magnetic field). Let E be the voltage between the ribbons, then E/d is the intensity of the electric field, where d is the distance of the ribbons apart. Let I be the current, then $4\pi I/w$ is the intensity of the magnetic field.[2] The total energy stream is EI ergs per second from left to right, or EI/wd

FIG. 1.



ergs per second per square centimetre. Substituting electric field intensity $f = E/d$ and magnetic field intensity $H = 4\pi I/w$, the expression for the energy stream in ergs per second per square centimetre becomes $\frac{1}{4\pi} \cdot f H$, which is the usual form in which Poynting's Theorem is expressed.

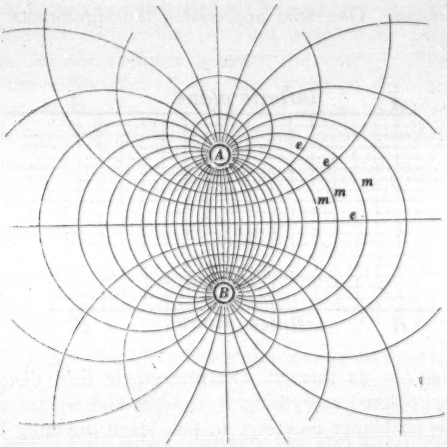
The following is a general statement of the transformation which would be necessary to reduce the usual expression for Poynting's Theorem to the familiar form involving voltage and current for the case of a transmission line consisting of two parallel cylindrical wires.

The two sets of curved lines $c\ c\ c$ and $m\ m\ m$, Fig. 2, represent electric equipotential surfaces and magnetic equipotential surfaces in the region surrounding two parallel cylindrical wires with a certain voltage between the wires and a certain current

[2] C.g.s. electromagnetic units are used throughout.

flowing in them in opposite directions. Imagine measurements in space to be so altered that the distance between equipotential surfaces is everywhere considered unity. Then the electric potential at any point is proportional to the distance (so measured) of the point from the surface of the wire A, and the magnetic potential at any point is proportional to the distance (so measured) of the point from, say, the plane through A and B. But when potentials are proportional to measured distances,

FIG. 2.



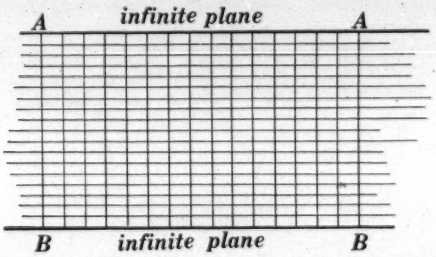
potential gradients are uniform; and therefore Fig. 2 represents in ordinary space what would be a uniform field distribution like Fig. 3 in space as above measured.

Let E be the voltage between the wires in Fig. 2, and let I be the current in the wires ($4\ \pi\ I$ is the magnetic potential-drop along any curve encircling one of the wires). Also let d be the distance between the wires measured as above explained, and let w be the length of any one of the curves $e\ e\ e$ in Fig. 2 (they are all of the same length when measured as above explained). Then E/d is the electric field intensity everywhere, and $4\ \pi\ I/w$ is the magnetic field intensity everywhere. The

total energy stream is EI, the entire sectional area of the energy stream is dw, and the ergs per second per unit sectional area is EI/dw, and this is equal to $\frac{1}{4\pi} \cdot f\,H$, exactly as in the above argument as applied to two broad, flat parallel ribbons.

The alteration of space measurement which makes Fig. 2 appear like Fig. 3 is the exact geometrical equivalent of the algebraic transformation which reduces the equations of the electric and magnetic fields around two parallel wires to the forms which express the electric and magnetic fields between two broad, flat metal ribbons. One who appreciates the significance of such

FIG. 3.



transformations as this, all electromagnetic field distributions look alike to him! everything is straight and square and uniform, it is no longer necessary to talk about anything but simplest cases, and the familiar equation of the electrical engineer, namely, *voltage* $\times$ *current equals delivered power,* is all there is left to Poynting's Theorem.

EQUATIONS OF ELECTROMAGNETIC ACTION.

The general equations of the electromagnetic field[8] are tremendously simplified by considering the case of a transmission line and using the generalized parameters E and I; and the

[8] The familiar equations of the electromagnetic field expressing time rates in terms of curl—for the simplest case, of course—are discussed on pages 60, 61, and 62 and in Chapter VI of Franklin's "Electric Waves."

integrals of these equations (the equations of the electromagnetic wave) assume a form, which for simplicity are equal to the formula for Ohm's Law.

The general equations are:

$$C \cdot \frac{dE}{dt} = \frac{dI}{dx} \qquad (1)$$

and

$$L \cdot \frac{dI}{dt} = -\frac{dE}{dx} \qquad (2)$$

where C is the capacity of the line per unit of length (the generalized [4] inductivity of the medium between the wires), and L is the inductance of the line per unit length (the generalized permeability of the medium between the wires). These two equations are easily derived by considering an element of the transmission line. The current which enters the element is greater than the current which flows out of the element by the amount $\frac{dI}{dx} \cdot \Delta x$, and this is equal to the rate at which charge is accumulating on the element of the line $\left(= C \cdot \Delta x \times \frac{dE}{dt} \right)$. The voltage across one end of the element exceeds the voltage across the other end by the amount $\frac{dE}{dx} \cdot \Delta x$, and this difference is the net voltage which is causing the current in the element to decrease $\left(= L \cdot \Delta x \times \frac{dI}{dt} \right)$.

The general integral of equations (1) and (2) involves undetermined functions of $(x \pm Vt)$, where $V = \sqrt{\frac{1}{LC}}$; but the simplest form of this integral may be established by imagining a current distribution over the line which *travels* at velocity V, and a voltage distribution which *travels* at velocity V, because the idea of travel is precisely equivalent to the use of the double variable $(x \pm Vt)$, as is well understood by everyone familiar with the equations of wave motion.

[4] It is assumed that the reader is familiar with the idea of generalized co-ordinates. If he is not, he cannot hope to understand much about voltage, current, capacity, and inductance.

Imagine a current distribution over a transmission line the value of the current at a given point being I. The magnetic flux between the wires of unit length of the line is LI. If the distribution is travelling at velocity V, then the flux LI moves unit distance forwards in $1/V$ second, the rate at which this flux sweeps across a line drawn from wire to wire is $LI \div 1/V$, and this is therefore the voltage E which must exist at the given point of the line so that

$$E = LIV \tag{3}$$

Imagine a voltage distribution over the transmission line, the value of the voltage at a given point being E. The charge on unit length of one of the wires is CE. If the voltage distribution is travelling at velocity V, then the charge CE moves forwards into the next unit length of the line in $1/V$ of a second, and therefore the current in the wire is equal to $CE \div 1/V$. Therefore the current which must exist at the given point of the line on account of the moving voltage distribution is

$$I = CEV \tag{4}$$

Now if the I in (4) which is due to the moving voltage distribution is the same I that produces the voltage distribution according to equation (3), and if the E which is produced by the moving I in equation (3) is the same E that produces the I according to equation (4), that is if E and I in (3) and (4) mutually sustain each other, as it were, then (3) and (4) are simultaneous equations, and by combining them we find

$$V = \sqrt{\frac{1}{LC}} \tag{5}$$

and

$$\tfrac{1}{2}LI^2 = \tfrac{1}{2}CE^2 \tag{6}$$

Now an unchanging distribution of E and I travelling along a line as here described constitutes a distortionless wave or a pure wave. Equation (5) gives the velocity of such a wave, and equation (6) shows that the electric energy in such a wave is always and everywhere equal to the magnetic energy.

THE OBSTACLES TO THE PROGRESS OF METEOROLOGY.[1]

BY

PROFESSOR CLEVELAND ABBE,

United States Weather Bureau, Washington, D. C.

LET not this title produce an unfortunate impression. I am not a pessimist. I see the great work that meteorologists still have before them and that their motto must be that of every student: "*Nil desperandum. Labor omnia vincit.*" Man must never despair.

We have all been so long accustomed to fairly accurate and very useful daily weather forecasts that we begin to look for perfection in long-range predictions. Let us be optimistic and believe that eventually these will come.

In addressing you many years ago I told you of the good work done by your own Franklin and Espy, and I spoke cautiously, but hopefully, of the future progress of our knowledge of the weather and of the atmosphere. In those days of small beginnings I assured those who wished for perfect long-range predictions that not only were they impossible at that time, but that mankind was not yet ready for them; they would do more harm than good, they would frighten more than they would help. But when the world is ready for them and able to profit by the truth, the whole truth, and nothing but the truth, then men will be found able to make forecasts as accurate as any one may desire.

All this is still true. In those days we dared only to speak of probabilities—now we say forecasts—but we are not yet justified in making predictions as to precise details of future local weather, such as the astronomer makes relative to the stars, or the electrician or the engineer makes as to the behavior of his machinery.

Why is it that our progress has been so slow? We have not been idle. Other nations have not done better or gone ahead

[1] Presented at the stated meeting of the Institute held Wednesday, November 15, 1911.

of us. The trouble lies largely in the inherent difficulty of our problems and the comparative complexity of our atmospheric conditions. It is a common saying that the more we study the atmosphere the more complex it seems; perhaps it is not yet clearly apprehended in its entirety. Just as a young student of medicine takes to pieces an ideal mannikin and is astounded to realize the very complex structure and still more complex physiology of the human body, so is the meteorologist amazed as the difficulties of the problem before him open up in his daily work. In 1846, Loomis, Redfield, Espy, and Bache assured Professor Henry that the time was at hand for the possible prediction of our storms with the help of the Morse telegraph. In 1854 he began this work at the Smithsonian Institution, and in 1868 I took it up anew at Cincinnati, but we never promised perfect work immediately, nor indeed within a lifetime. Filled with faith in nature and man, we could only *begin* the work. We knew that the perfect fruition of our labors must be left to future generations and future centuries. You yourselves may not see it all in your day, but it will surely come to us—as it has come to astronomy, optics, chemistry, and many other branches of knowledge. A work has been begun that the world will not willingly let die.

During past centuries students have given great attention to *climatology*, the average pressure, temperature, and rain, the average winds, and even the climatic diseases that affect the life and health of animals and plants. These matters form the special features of each locality. If the average temperature should vary from century to century we might recognize a steady cooling or a periodic variation, and we would feel justified in making a corresponding forecast for the century to come. But in fact no such periodic variations have as yet been satisfactorily demonstrated. There are indeed thought to be a so-called eleven-year period corresponding to sun spots, and a longer period in temperature, called Brückner's period of thirty-five years—but the variations in temperature during these periods are too slight and as yet too uncertain to neutralize my previous statement. Why can we not definitely establish the existence of such periods in our local climates? Why? Possibly they do not exist; but even if they do exist, they are so completely covered up by the defects of our own observations and records that it would

require many thousands of such records as we have to assure us that their inherent uncertainties counterbalance each other, and that a computed period exists in nature and is not a mere appearance due to our fumbling with figures.

In general, throughout the world, observations have been at fault because instruments have been faulty, or exposures have been changed by the growth and disappearance of buildings and trees. Change after change prevails in all human matters, and such changes affect the work of the climatologist. It is hard to detect minute periods when the records at any one spot are usually kept up for only a few consecutive years and then a new observer, at a new nearby location, with new apparatus, and possibly with new hours and new methods, takes up the work.

Illustration (1). We have a long record of temperature and weather in this very city at the Pennsylvania Hospital. From the annual means of this record we may deduce several interesting coincidences and relations, correspondences and periodicities during past years, but every attempt at accurate forecasts of temperature, either daily, monthly or annual, based on these simple statistics turns out to be elusive—and this is true in all other cases that I know of. The errors of apparatus and changes of exposure combining with the irregularities of temperature are larger than the forecasted changes and the latter turn out to be unsatisfactory.

Illustration (2). About 1820 the German meteorologist H. W. Brandes excited a new interest in forecasting by compiling a few daily maps of the meteorological conditions throughout Europe. His work was equivalent to showing that large areas of land must be considered in all meteorological studies; this is the principle now adopted in all modern forecasting.

Illustration (3). Thus when the question of the possibility of changes on the earth corresponding to spots on the sun, was discussed by Koeppen in 1881 he compiled his data for the whole world, especially the northern hemisphere, and for all the years of accurate record since 1640 and even then Koeppen found no relation except one. The elusive nature of even this one has been demonstrated by Schuster, who shows it would require far more and far better material than Koeppen had to establish any sun spot influence. Prof. Simon Newcomb's work on this sub-

ject seemed to show that the influence of the sun's spots, or his general spottiness, on the temperature of the earth is insignificant; and yet there can be no doubt but that there is a general suspicion or belief that the solar spots have some relation, direct or indirect, to all terrestrial phenomena.

Illustration (4). As with the sun spot periods so also with lunar periods. If the sun or moon produces any direct periodic influence on the climate of any part of the earth, or on the earth as a whole, these periodical influences seem insignificant and it is quite impossible for us to recognize them in the presence of other disturbances which introduce all sorts of larger irregularities and perhaps temporary periods in the local observations. We are safe in saying that long range forecasts of any magnitude, and short time daily forecasts of any value, cannot be based on solar or lunar periods.

The improvement of climatological records is a minor branch of dynamic meteorology; but even this is not an easy matter: it does not depend wholly upon finances or on personal enthusiasm, nor on obedience to official orders.

Illustration (5). For instance dynamic meteorology needs the average temperature of large masses of freely moving air; hence we should put our thermometers on the tops of high buildings. But every year sees taller buildings erected in our important cities. It is as though the ground in Philadelphia, or New York, or Chicago, were rising up to the level of our self-recording thermometers. If we elevate these latter, the local citizens, hygienists and agriculturists complain that they want temperatures near the ground where men live and where plants grow and that a station two hundred feet above the ground does not suit them. Do they not forget that at the ground the temperatures around their feet are often quite different from those at their heads? That the temperatures on the shady side of the street differ from those on the sunny side, and that temperatures in a valley differ from those on the hillside? We meteorologists are studying the temperature of the free air in connection with clouds, rains and storms,—while they are thinking of crops or personal health and comfort.

The conservatism of climatologists and hygienists opposes the best interests of progressive forecasters and meteorologists, properly so-called.

Illustration (6). It is the same also with the wind pressure

and the wind velocity. The student of dynamics needs the data from the free air, and the clouds, therefore, he raises his anemometers high above the tallest buildings or puts his stations on the highest hills. The records of these instruments are so difficult to understand that many inventors have devoted years of experimentation to convert the anemometer readings into true wind velocities. But meanwhile the steady increase in the elevations of tall buildings, and the growth of trees at all country stations, make it impossible to consider the records of to-day as being truly homogeneous with those of twenty years ago.

Illustration (7). The case is even worse with regard to rainfall. The rain gage is certainly the simplest of apparatus, a mere cylinder set up to catch the falling rain and snow. We measure the depth of the water in the gage and that is all there is to the observation and record. But this simple apparatus, which has no inherent instrumental error, is open to such serious sources of error that its indications and the averages of years of observations may easily be misleading. These errors have their source in the two-fold influence of wind at the locality, and at the gage. Every building or hill is an obstacle to the wind. We place the gages near the ground in an open clear space, or on a post, or on the top of a tall building. The wind sweeps around and over the building, or the hill, and carries the rain or snow to the leeward so that only a few large drops fall on the spot where the gage is located. Equally so the gage itself becomes an obstacle when placed in a clear windy spot and all the smaller drops of rain are carried over it and beyond it, so that a perceptible percentage misses being caught and measured. The remedy for all this was long since pointed out by your own Professor Joseph Henry when Secretary of the Smithsonian, who cut off the wind from the mouth of the gage and now we have various devices for this purpose constituting the "protected rain gage." But how very rarely do the thousands of rainfall observers protect their gage records against this source of error, which, on the averages of 10 gages in England whose altitude is 200 feet where strong winds are likely to prevail, amounted to a deficit of about 50 per cent., diminishing thence to 6 per cent. for elevations of three or four feet in European gages, for rain only, but amounting to 100 per cent. in the case of light rain or snowfall and strong winds.

What false conclusions are we not liable to draw when study-

ing climatological data subject to such errors? It is to such misleading records as these that we must attribute the origin of that widespread fallacy that "forests increase the quantity of rainfall." They do indeed increase the catch of the rain gage, by diminishing its loss due to the action of the wind at the mouth of the gage, but the actual rainfall is not affected by forests. The winds that sweep over our western plains often swirl nearly all the rain and snow out of the gages; modern records with gages better protected from the wind by trees, fences, and buildings, give larger annual precipitation than formerly; but this does not mean that the climate has changed.

Illustration (8). These strong winds may have a very decided deleterious influence on our records of barometric pressure, so that here again is a weak point in the comparison of long continued records at some of the most interesting observatories in the world, namely, those located in very windy places, as on the mountain tops, or at sea coast island, and such spots as Point Reyes Light near San Francisco. Barometers are usually fastened against the walls or on solid piers in some room of a fixed building. The normal standard barometers are so constructed that every minute source of error inherent in the instrument may be carefully determined and allowed for, so that the pressure of the atmosphere within the room may be known to within a thousandth part of an inch or one ten-thousandth part of the length of the vertical column of mercury, which is usually about thirty inches long. But this so-called static pressure within the room is not necessarily the same as that in the free air outside the building, because the building is an obstacle to the wind. If the doors and openings are all closed and one window be opened on the windward side the barometer will be at once seen to rise by reason of the added pressure due to the wind pressing against that open window, whereas the pressure will fall if a window be opened on the leeward side. But if all ordinary openings and leaks are closed and the chimney alone is left open, this chimney becomes the important obstacle and the stronger the wind, so much the stronger the suction up the chimney, if the latter be properly built, or the pressure down the chimney if it be improperly built. The influence of an 80 mile gale is about half an inch of barometric pressure on the scale of the mercurial barometer, or a quarter of a pound pres-

sure per square inch. Studies into the influence of chimney-tops on the draft up chimney, and therefore on the pressure within the room at the fireplace were carried out most elaborately by a special committee of the American Academy of Science in Boston, about 1847, and with equal energy by your own committee, as reported in the JOURNAL OF THE FRANKLIN INSTITUTE, Vol. IV, 1842. Your object was to teach us how to improve our chimney drafts, but who thought of teaching us how to escape their deleterious influence on our barometric records? The mariner often speaks of the oscillations of his barometer at sea, "it pumps with every gust of wind during a hurricane," but our delicate aneroid, or self-registering barometer, is much more sensitive than the sluggish mercurial and what should be a delicate curved line, on our recording sheets, often seems a mere broad blotch of ink. Thus the study of the relation between the pressure that prevails in the free atmosphere and the corresponding free wind velocity, or free wind pressure, is complicated with uncertainty as to what the barometer is recording. It is quite common to build an observatory on the top of a mountain, or hill or a ridge, in such a sheltered position that the prevailing violent west winds striking the ridge bound over it and over the building which is thus sheltered by it. In other words the building is located within a small region where the wind pressure and the barometric pressure are both of them lower than they would be if the barometer were located in the free air, and were floating with the wind like a free balloon. We ordinarily say that a portion of the kinetic energy of the moving wind is given up to the ridge as an obstacle increasing the static pressure on the windward side, while the barometer records a deficit in the static pressure on the leeward side of the ridge.

To the unaided eye a very pretty evidence of the existence of such regions of low pressure is given when the observer notes a little cloud like a streamer attached to the mountain-top on the leeward side. This is a region of deficit of pressure into which outside air under higher pressure has been pushed and this air expanding and cooling, just as ordinary clouds are formed, forms a beautiful delicate "banner cloud" full of internal commotions.

In the Hartz Mountains of Germany a cloud is often to be seen forming what is called the Spectre of the Brocken due to

the expansion of moist air into these so-called discontinuous spaces.

I have spoken of some insidious instrumental and local errors that are still creeping into our climatological records all over the world. In former ages these matters have been equally serious, so that all records since the first organization of meteorological work, about 1640, by the disciples of Galileo and after his death, need to be carefully scrutinized before one dares to compare them together and draw fine conclusions as to changes in *climate*, or as to the relations between local climates and the various theories that have been suggested about the influence of the sun or the moon, or comets, the forests, or battles, or auroras, or the cultivation of the ground, or any other suggested cause of possible changes in the earth's atmosphere and climate.

The greatest climatic change that we know of is that which seems to have occurred when the earth passed through that geological epoch known as the glacial period, when snow and ice a mile in depth covered what is now known as our Lake Region and when similar phenomena occurred from time to time in Europe, in New Zealand, and even in Central Africa. We are at present wholly at a loss to demonstrate the value of the various suggested explanations of such great changes in local climate. How can we expect to reason from our little possible climatic changes of one degree F. or one inch of rainfall, or an occasional cold winter, back to those ages during which the whole face of the earth was changed!—and yet even then man was living on the earth?

The errors of instruments, and of their exposures, the shortness of each local record, the limitation to stations on the globe at the very bottom of our atmosphere, the limitation to habitable parts of the globe, depriving us of extended records on the ocean, or in the deserts, or in the polar regions, with only here and there an occasional record brought down from high altitudes by kites or balloons, are, however, but minor obstacles to the progress of meteorology.

Not long since (1892) Prof. Arthur Schuster, at the British Association for the Advancement of Science, discouraged by the slow progress of our knowledge of the peculiarities of our atmosphere, exclaimed, almost in these words: "Why not stop

all observing and recording and the daily predictions, for five years, and devote ourselves to *study?* Why not relieve our numerous National Weather Bureaus from their previous onerous statistical work and turn their best men into the study of the physics and mechanics of the earth's atmosphere? Why ask a blind man to observe and record without knowing why or what?"

Of course we would not forget that local climates and their influences on humanity, have for ages occupied the attention of mankind as *climatology*. There is a demand, a steady daily demand for daily data. At first forecasts of storms and weather were an application of our elementary statistical knowledge of general climatology, were not based on our knowledge of mechanics, because we know so little of this latter science as applied to the atmosphere. We believe that the fundamental laws of forces must be still better understood than now, before we have any right to expect detailed predictions at such long ranges as are possible in some other professions.

But let us pass from considering climatology or the average condition of the atmosphere and statistical conditions. Suppose that we really had perfect observations and records for ages past, would these alone enable us to make accurate long range predictions as to the future? No, indeed! not even though our kites and balloons do record whatever goes on ten or fifteen miles above us. Not even though our daily weather maps cover the whole of the United States and the oceans on either side of us, including the corresponding daily weather maps for all Europe and Asia. Daily maps for the whole Northern Hemisphere for both land and ocean were published formerly by us for about ten consecutive years, showing all about the successive conditions of the weather. We may always obtain sufficient observational material for these, but how can accurate predictions be made from the most perfect graphic maps and statistical figures? We may indeed estimate the probabilities, but the great obstacle that hinders perfect predictions is nothing less than our ignorance of many details as to the laws that govern the atmosphere and our inability to put even what little knowledge we have, into such a form that it can be promptly utilized by the forecaster.

I do not consider our present system of forecasts as being

faulty either in Europe or America. Such good men as are now engaged in this work, throughout the world, cannot do other than *good work*,—the very best that is now possible under existing conditions. I am not criticising the good that we have, I am asking you to seriously consider what can be done to help meteorologists throughout the world, onward toward perfection in the distant future.

Now and then you will find a man who by persistent practice and long familiarity with his billiard table, his balls and his cues and his strokes, can tell with delightful precision just when and where a ball will land; equally is this true of the pitcher in baseball, or the man at the helm of a great steamship, or the pilot of an aeroplane. These all get at the desired result after many trials and failures; they acquire a knowledge of the motions of things without much knowledge of the fundamental laws that govern moving bodies; they have a so-called practical knowledge without the theoretical. Hence the experience of the billiardist may be very useful in *some* new fields of work, such as baseball, but how can it apply to some distant field of work, such as the motion of a flood in the river, or the advance of a rushing blizzard? I recall vividly the agitation scattered throughout this country by the newspaper press of 1851–5, relative to the rotascope of Prof. W. R. Johnson, then of Philadelphia, and relative to "the mechanical paradox" of Prof. Jonathan Homer Lane, that brilliant light among the scientists of Washington, all which instruments are now well known as the gyroscope of Foucalt. "A new force has been discovered," said one popular writer; "falling bodies are made to rise and move horizontally; Newton's law of gravitation is not universal," said another. And yet the puzzling movements were easily explained by the laws of rotation that had long before been expounded by Poisson. So little were these laws of motion then known to the professors and students of our colleges that many, like myself, were staggered as to their faith in the teachings of Sir Isaac Newton and began to inquire whether it might not be possible to undermine and upset all the wisdom of ordinary learned men. No, this is not possible. The future may enlarge or perfect our present knowledge of nature. We may impose new conditions and attain new results, but we shall merely clarify our present wisdom, we shall add to, but not upset, all the teachings of the past. He who pushes on

over the mountains and discovers new uplands, does not destroy the lowlands that he left behind.

If one depends only on the daily weather maps and knows little or nothing of nature's laws he finds himself in a maze of limitations. He dare not prophesy; he ventures only to say that "judging by the general behavior of the atmosphere, during the past few hours, it may be expected that," or that "the indications are," or "the probabilities seem to be that so and so will happen." Must we then imitate the self-confident sooth-sayers, haruspices, augurs, fortune-tellers? Shall we look to the birds and animals and plants, for a little of their wisdom?

Do we not know that our atmosphere is an inert machine, controlled by the same laws that govern all machines? It is simply a very complex air engine, in which the air is warmed by the sun, and cooled by radiation. The denser air pushes the lighter air aside and keeps up the circulation. Can not man's intellect unravel the complex of combinations that are changing every hour of the day and every day of the year? Of course this immense machine is a whirling globe, revolving daily and feeling the influence of its own centrifugal force. It is rushing around the sun annually through the inter-planetary space, so that it is affected by shooting stars, solar electrons, inter-planetary æther and exceedingly thin unknown gases.

Consider for a moment the fact that the atmosphere is a mixture of gases and vapors, each of which has its own peculiarities so that we must especially consider the presence of water and ice and their vapors. All its constituents are subject to the laws of thermo-dynamics, by reason of which gases cool, when rising and expanding, and warm by descent and compression; they are all subject to the laws of hydro-dynamics, by reason of which cyclones, tornadoes, blizzards, trade winds and calms, must occur; they are all subject to the laws of radiation and absorption of heat, by reason of which low lying fogs are formed and also the great stratum of relatively warm air that surrounds the globe about ten miles above sea level.

The laws of radiation of gases and motion, of pressure and vapor diffusion, are understood at present only well enough to enable us to progress very slowly in the fundamental part of the physics of meteorology. In the ordinary physical laboratories of our universities, our best men, with expensive and accurate

apparatus, study these laws separately, or by simple combinations among themselves. But the meteorologist can not experiment with the atmosphere as a whole, as he would like to do. However, he can experiment with relatively small portions of the atmosphere and deduce conclusions that can be applied on a large scale to the data given by the daily weather map.

Of course our progress in the work must be slow but steady. Do not the remains of animals found in the depths of the earth show that the Creator spent ages in gradual approach toward the construction of such perfect birds of flight as the condor, the eagle, the carrier pigeon? Man has spent only the past thirty years in his persistent efforts to rival these creatures. They are flying by virtue of their material construction, their inherited wings and muscles and nerves, but man must learn to fly by virtue of some intellectual conquests. He must not expect to do in a few years that which the birds required ages to do. They have only an *art;* we must first understand the science.

It is the study of nature and nature's laws that must constitute the basis of all our future progress in every science. These laws are hidden from the eye and the ear, from the touch, the smell and the taste, they are not revealed to us by our material senses, but only by intellect and reason. Our imaginations suspect their existence; we begin with the conviction that there must be a cause or a reason for every phenomenon. We try various hypotheses and after testing them all, some of them become established as realities shown to accord with all the observed facts. It is this intellectual ability that constitutes the basis of man's power over nature: without it man cannot develop the mechanical principles that apply to this atmosphere.

Behind every perfect practical art and every ordinary act there is a higher science that must be understood if we would have full command of the world around us. This material world is so permeated with evidences of a wonderful creative power that we must recognize ourselves as following far behind trying to discover how things were done and how puny man must do if he is to accomplish his plans. Our minds can not think, our brains can not act, except in harmony with the properties of the atoms of which our bodies are composed; all our thoughts must be in harmony with the mechanical laws that govern those same atoms as they circulate in the inanimate nature around us. There

is not a mode of motion which the mind can imagine as possible but what is actually found to be present among the atoms studied by the chemist and the physicist.

Was Sir Isaac Newton satisfied to know that an apple falls from the tree to the ground, or that a stone flies from the whirling sling when it is let loose? Ah no! His imagination penetrated beyond these well-known material phenomena. He imagined various general laws that might govern the motions of the apple and the stone, and demonstrated to the satisfaction of all men that *inertia, momentum, gravitation, centrifugal force* prevail throughout the universe; that they control the motions of atoms, the phenomena of light and the revolution of the planets about the sun.

Similarly did Sir Robert Boyle reveal the law that liquids and gases press outwards in all directions and that this pressure is equal at every point of the inclosure upward or downward or sideways.

The progress of knowledge in every direction has led us from the visible phenomena of everyday life, through the telescope up to the stars; through the microscope down to the microbe; through the prism and iceland spar up to that interplanetary substance called æther that brings us light and heat from the sun. Through chemistry we have learned about the combinations of atoms and molecules; through the steam engine we have learned the laws of thermo-dynamics; from the old electric battery we have ascended to the study of the electron, and the ultimate corpuscles of all matter; through photography we have come to study radium and the X-rays. Now all such study is done by manipulation in laboratories devoted to these subjects. But it is also brain work; it is the spirit of mathematics that guides us into the airy realm of the mechanics of molecules and the structure of all matter. The intellectual process called logical reasoning, which is generally mathematical, leads us up to the laws of the forces of nature, which laws themselves are, so far as we now know, perfectly non-material, not to say intellectual and spiritual.

Mathematics is really the laws of thinking as distinguished from mechanics, which is the laws of forces. We speak of thinking as an intellectual process wholly confined to the mind or brain, but the atoms of the brain are regulated by the very same

laws of mechanics, so that thinking is but expressing in words the mechanical processes going on among the atoms of the brain, or if you will, the matter of the whole universe. We and nature are one. As successive generations of men devote their intellectual powers to the mechanics and mathematics of nature, we shall gradually unfold all the secrets of nature and elucidate all the phenomena of meteorology that now seem so obscure and difficult.

A recent address by Professor Moeller, of Brunswick, Germany, who has written much on the problems of the movements of the atmosphere, has enforced the need that is felt in that country of courses of study specially designed for students who wish to devote themselves to meteorological researches and the increase of our knowledge relative to the atmosphere.

Possibly the first step ever taken to specifically provide for future researches on the atmosphere was by that earnest philanthropist Thomas G. Hodgkins of New York, who willed his fortune to the pursuit of this one study in all its relations to mankind. Therefore the Smithsonian Institution as his executor has aided and published a large variety of atmospheric researches and may be expected to publish still more in the future. Even the Carnegie Institution has done a little for meteorology by printing one volume on dynamic meteorology by the most advanced, enthusiastic and stimulating of all living students, Victor Bjerknes, of Christiania, Norway.

It is not merely a publisher that is wanting. It is the laboratory with its corps of thinkers and experimenters—men who have done and are able to do still more,—the so-called mathematical physicist, full of enthusiasm and profiting by the stimulus of a few companion students.

In the special field of electricity ideals could be mentioned, such as the Cavendish Laboratory at Cambridge, England. Here J. J. Thomson and his group of students remind one of the ancient peripatetic school of philosophy held by Socrates at Athens, so far as concerns the close communion of spirits; or the glorious Academia del Cimento at Florence, where the disciples of Galileo had buildings and apparatus adapted to the close study of natural philosophy. Something of this kind I would see devoted to the advance of atmospherics.

Am I looking too far ahead? Shall not some of us now living see the establishment of some such school devoted to the

physics and mechanics of the earth's atmosphere? Our great universities have their schools of mathematics, chemistry, physics, engineering, etc. Annually they turn out innumerable successful candidates for the degree of Doctor of Philosophy. These young men by their published theses show that each knows all of some one special subject and has added thereto discoveries or improvements of his own. They become adepts in such researches and are quickly sought by the various business concerns that need their knowledge and their talents. Almost all the progress of modern times has been due to the works initiated by such men and by their teachers in special laboratories. It is precisely such men and such talents for research that I would secure for the study of obscure atmospheric problems. I would have them furnished with an extensive laboratory especially adapted to atmospheric studies. A study now often confounded with aerology, but which I would rather call atmospherics. I do not specifically suggest an establishment devoted to the aeroplane or aerial navigation. This is a specific engineering problem, that many nations are providing for on account of its prospective importance in warfare. Possibly the aeroplane will become as useful to meteorology as the kite and balloon have been. But atmospherics has other needs than those of an aerial navigation. To be sure, we do need observations made in the atmosphere itself, but still more do we need a building wherein to imitate atmospheric phenomena so that they can be measured and subjected to mathematical study.

(1) Suppose one wishes to find out all about water-spouts, or thunderstorms, or tornadoes. Must he go *to* them and *into* them? No; he can cause small ones to form in such a laboratory under specific conditions that he can control. I have seen a beautiful experiment of this kind performed in Paris. One has only to rig up a horizontal whirling wheel and place a dish of warm water on the floor directly below it. The vertical spiral spout is quickly formed and the student with his little pieces of measuring apparatus can determine the pressure, temperature, moisture and wind, at every point within it. He is supposed to have previously prepared analytical formulæ that pertain approximately to just such a water-spout and he now compares his observations with his theory. Doubtless he will have to modify his formulæ until he attains those that will apply on a large scale to the air in a natural water-spout. He thus acquires

confidence in his knowledge of mechanics and his ability to demonstrate its agreement with nature.

(2) The beautiful clouds change their structure and their features with every approaching change in the weather. We can reproduce many of these in a proper laboratory and determine more precisely just what these changes mean.

(3) The formation of rain, snow, hail, and frost must be imitated until we know how and why they are formed.

(4) The beautiful smoke rings, or vortices, sent straight upward by certain cannon that are used to prevent hail, must be studied in a laboratory until we are able to show why it is that neither they nor the explosion of dynamite have any influence on thunder clouds or hail.

(5) The absorption of the solar rays by the air, the earth, the ocean, and the fields of snow, and in general the distribution of temperature on the globe, even the formation of glacial epochs, can be investigated experimentally, as well as by the present imperfect theoretical hypotheses.

(6) We can go further than small local phenomena. Models must be made of the whole globe or of its two hemispheres, bedecked with close imitations of our continents, mountains, oceans, clouds and atmosphere. These must revolve all together in imitation of our daily rotation, and we must be able to measure everywhere on our models, the pressures, temperatures, winds, the little eddies like our hurricanes, that move along the surface of the earth and the advance of great blizzards, or floods, or droughts. (All of which I explained in the Monthly Weather Review of December, 1907, and in the Bulletin of the American Mathematical Society, in July, 1907.) Thus we shall elucidate the motions of areas of low pressure and rain, eastward around the globe, from Japan to Russia, or from Cape Horn to Australia. We shall understand the influence of the Andes and Rocky Mountains, or of continents and oceans, on the general circulation of the atmosphere. We shall go on further and study the behavior of our upper atmosphere that is so very different from the lower half, in which our ordinary phenomena originate.

Time would fail me to describe all the beautiful, but confessedly difficult experiments, that can be made with gases and vapors in the laboratory for atmospherics; with all these experiments there must go on a truly difficult mathematical work.

Thirty years ago, the best mathematicians told me that our problems were too difficult for them, but now younger men have attacked them, and the experimental laboratory will enable us to test these newest results and will give us confidence in the application on a large scale of the results of experiments on a small scale.

If the preparations for such experiments were not so laborious and expensive, I should to-night have illustrated this plain talk by showing you some of them so that you might realize that I am not promising work beyond man's ability to perform.

In conclusion, I must say that what I most long to see, and what I believe is of fundamental importance, in atmospherics, the want of which is a real obstacle—is the existence of a laboratory building specifically adapted to atmospheric experiments and the association therewith of able students trained in mathematics, physics, and mechanics. When all this is realized the intellectual work that will there be done, will gradually remove all obstacles to the eventual perfection of our knowledge of the atmosphere.

Does this seem like a long look ahead? Not so. The time is ripe for the institute. Many eyes are looking for its appearance. It matters little whether the ideal be realized by our own Weather Bureau at its important research station on Mount Weather, or by the German Weather Bureau, at Lindenberg, or by Mr. Rotch at his private station on the Blue Hills near Boston, or under the auspices of some wealthy university, which latter would seem to be a most congenial spot. Or whether the Smithsonian and Carnegie Institutions shall add it to the galaxy gathered about them. *All are welcome.* There is room for several such laboratories of atmospherics and for many busy men in this class of work. Every man and every institute will be helpful in its own way. Each must plan for many years of labor, as is the case in astronomical observatories and all other scientific institutes. Man has to *make haste slowly*, when he studies nature.

If ever the state should honor those of your citizens who have done so much for meteorology, the names of Benjamin Franklin, William Ferrel, Alexander Dallas Bache, Walter Rogers Johnson, James Pollard Espy, Robert Hare, and Elisha Kent Kane, will be inscribed on the portals of some future laboratory devoted to atmospherics.

Paper Specialties. H. POSTL. (*Papierfabrikant,* ix, 853.)—*Japanese papers.*—Genuine Japanese papers are not made from rags, but only from freshly-prepared native bast fibres. These bast fibres receive only a very gentle chemical and mechanical treatment; the bast is steeped in dilute alkali, and cleaned by hand, and beaten by hand with wooden mallets: the Hollander machine is not employed. Hence the fibres retain all their natural qualities and strength, and as no bleaching chemicals are used, Japanese papers are noted for their great strength, and have a silky gloss and feel, and are excellent for printing. Attempts to use native Japanese fibres in Europe have been unsatisfactory.

Dutch tobacco paper.—The qualities demanded are: light and permanent color, great resistance to crumpling and creasing, and complete absence of holes or thin porous patches through which the moisture and aroma of the tobacco might escape. This paper is made from cotton and linen rags mixed with waste paper of the best quality. The web is run on a machine with two wet presses, and is cut into sheets by a machine in front of the last wet press. The moist sheets are taken off by hand and dried in lofts; they are sized, and plate-glazed as in hand-made papers.

Imitation hand-made cardboard.—This is used for covers, for pamphlets, etc., and must have deckle edges and a pronounced grain. Tinted boards in fast colors are best made from colored cotton rags, to obtain the desired thickness. To define the deckle edges, strips of waxed cloth are attached to the wire of the cylinder machine. Each sheet passes through the press between two marking felts, which impress the desired grain on the boards. Drying is done in the air or by slightly-heated cylinders. Generally engine sizing is enough, but in some cases tub sizing is applied.

Imitation parchment paper.—Previously the characteristic appearance of imitation parchment paper was obtained by the use of paraffin, stearin, starch, or glucose, but now this result is produced by the selection of a strong, well-boiled, sulphite pulp, suitably treated in the Hollander. The knives of the beater roll are of bronze and the bed plate is made of hardened cast steel ribs or basalt lava. Sometimes both roll and plate are of lava. The wire of the paper machine should be very long, with several suction boxes. The drying cylinders should be of ample capacity and so designed that not more than 100 kilos of paper are dried in 24 hours per square meter of cylinder surface. This slow drying is essential to give a strong and flat paper.

Parting of Platinum-Gold-Silver Bullion. ANON. (*Engin. and Min. J.,* xcii, 259.)—The bullion should contain more than 75 per cent. of silver. Nitric acid must not be used for parting, as, in the presence of silver, platinum would be partially dissolved. Sulphuric acid, free from chlorine, should be used in the proportion of two or three ounces of strong acid to one ounce of alloy.

WHAT MAKES WHITE LEAD CHALK AND HOW CHALKING MAY BE PREVENTED.[1]

BY

HENRY A. GARDNER,

Assistant Director, The Institute of Industrial Research, Washington, D. C.

Chalking and Repainting.—The chalking of white lead is one of the evils attending the use of this valuable white paint pigment which the master painter is most anxious to correct. Every fair observer will probably admit that moderate chalking is not objectionable, as it leaves a surface for repainting which will quickly receive and amalgamate with the new paint applied; this result being difficult with an old painted surface which is excessively hard or brittle. Excessive chalking, however, which is often followed by deep alligatoring and gradual disintegration, should be avoided if possible, for no matter how good a paint may be placed over a deeply-checked surface, the result is always unsatisfactory and unsightly.

The writer has recently read with interest a pamphlet which attempts to explain the cause of the chalking that is exhibited by nearly all pure white lead paints after exposure to the elements. In the article referred to, some very interesting theories have been advanced, and the object of this paper is to briefly outline these theories and discuss them in the light of the most recent knowledge obtainable on the subject.

Oil Conservation or Oil Substitution.—It has been stated in the pamphlet referred to that the chalking of white lead is due to the lack of linseed oil, and that chalking would not take place to any extent if white lead paints were mixed with greater quantities of linseed oil. From an economical standpoint, it would appear to the writer that if painters were to follow the above suggestion and use greater quantities of linseed oil than is at present the prevailing practice the effect would not be towards relief from the present high prices which must be paid for pure oil, and might not only encourage the use of linseed oil substi-

[1] To be read before the Convention of the Pennsylvania State Association of Master Painters, Scranton, Pa., January 18, 1912.

tutes which have not been thoroughly tested, but actually lead to the use of such substitutes.

Short Oil and Long Oil Reductions.—It has further been stated that not only the priming coat of white lead but the top coat as well should receive very long oil reductions in order to form a film which would protect the pigment from the elements, which are the initial cause of chalking when lead is applied with the usual short oil reduction. The application of ordinary white lead paint has been compared with the application of short oil varnishes which contain quantities of gum with very little oil, the analogy suggesting that the same enduring results which are obtained on exposure of long oil varnishes would be obtained if lead paints were reduced with quantities of oil. Commenting on the above procedure, it would appear to the writer that the use of larger quantities of oil than are at present in common use would result in a paint deficient in hiding power and strength. Furthermore, the comparison of varnishes with paints is not justified, as a varnish which consists of gums dissolved in oil is an entirely different material from an oil in which pigments are simply suspended. Both of these materials must be studied along separate lines, as they are physically and chemically different.

Amount of Oil Determined by Pigment.—It is well known that linseed oil, or, in fact, any oil, when spread into a paint films to a coating which upon exposure does not possess any very great strength or moisture-excluding power. When linseed oil, however, has been ground with pigments, the strength of the films is increased materially, and the greatest strength is developed in those cases in which a critical percentage of pigment has been added to the oil. The critical percentage varies with the nature of the pigment, a small quantity of some pigments being sufficient, while a large quantity of other pigments is necessary, to produce films of maximum strength. An average paint consists of ten pounds of pigment suspended in one gallon of oil, but the writer has in mind at present a paint made from thirty-five pounds of pigment suspended in one gallon of oil. This pigment, namely American vermilion (basic chromate of lead), is probably the lowest oil-carrying pigment ever produced or applied under actual practical conditions, and to-day, after nearly four years' exposure along the Atlantic coast, where it has been sub-

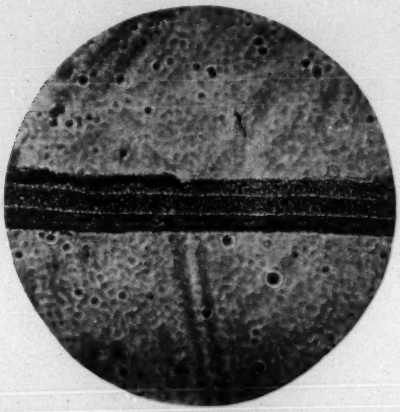
jected to the most severe atmospheric conditions, it is in almost perfect condition, showing absolutely no chalking. Being a lead pigment and being applied with a shorter oil reduction than white lead has ever been applied with, the result would seem to dispose of the theory advanced that white lead should be applied with longer oil reductions. If the amount of oil and not the amount of pigment should determine the service of a paint, would not a pigment such as asbestine, which requires enormous quantities of oil, form a paint more durable than white lead or any of the other white base pigments? We all know, however, that this is not wholly the case, and, moreover, we must look at the question in a practical manner, for the hiding power of a paint is one of the most important properties.

Hydrate and Carbonate.—The percentage of lead carbonate in corroded white lead determines its hiding power, while the percentage of hydrate determines the oil-carrying capacity. When the amount of carbonate runs to 80 per cent., the lead has a high gravity and takes only 3½ gallons of oil to a hundred pounds of paste lead to produce an easy-spreading paint that will have good hiding properties. When the amount of carbonate in corroded white lead drops to 60 per cent. and the hydrate reaches 40 per cent., difficulty in grinding is observed, even if additional oil is added. Such a product is likely to harden and become gummy in the package, and upon thinning 100 pounds of paste for application six gallons of oil are required and the product has only slight hiding power. Corroded white lead that contains about 70 per cent. lead carbonate and 30 per cent. lead hydrate is probably the best grade that can be obtained; its oil absorption is medium and its working properties and hiding power excellent.

Amalgamation.—The claim has been advanced that the application of long oil leads in repainting work is desirable, on account of the penetration into the old paint that can be secured from the newly-applied paint, both amalgamating to form one solid film. If this phenomenon really took place under such conditions, a cross section of the film produced would probably appear under the microscope as one solid mass of pigment and oil. As a matter of fact, this is not the case, as an examination of the photomicrographs that follow will show.

The Effect of Tints on Durability.—It is very generally admitted that tinted paints are far more durable than white paints.

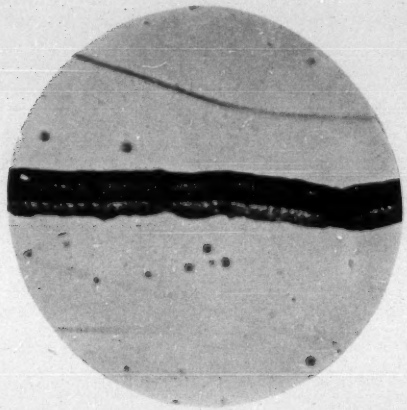
In the article under discussion, the claim is made that the increased durability of tinted paints is due entirely to an increase of oil brought to the white paint by the coloring pigments, all of which have rather high oil-carrying properties. As a matter of fact, however, the amount of oil carried into a white paint by one or two per cent. of tinting color is too small for consideration and is quite insufficient to give the result claimed above. White leads made by various processes take up varying amounts



Photomicrograph of cross section of paint film. Distinct layers in three-coat work are shown

of oil, 100 pounds of some paste leads requiring only 3½ gallons of oil, while in other cases leads made by different processes require as high as 6 gallons of oil to produce paints of a relative consistency. Upon exposure of such leads, there seems to be no material difference in the way they wear. This result would further indicate the fallacy of claiming that the extra durability obtained from tinted paints is due to the slight increase of oil brought to them as a contribution from the coloring matter used. We must attribute the greater durability of tinted paints, therefore, to the nature of the added tinting pigments and to the differing physical and chemical properties which they bring to the white base.

Carbonate and Oxide Pigments.—The carbonate pigments, such as lead carbonate, calcium carbonate, and barium carbonate, will all chalk when painted out and exposed to the elements. This chalking seems to be a distinct feature of the carbonate pigments. While it is true that certain other pigments which are not carbonates chalk quite heavily, it is furthermore true that the exception proves the rule. Pigments which are not carbonates, but which have other radicals, and which will probably

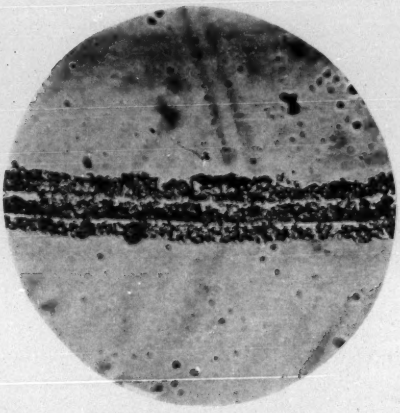


Photomicrograph of cross section of paint film. Distinct layers in three-coat work are shown.

be more readily recognized if called by their trade names, such as red lead, zinc white, litharge, etc., do not possess chalking tendencies, and they form paints which remain hard and glossy under long exposure. When either carbonate pigments or oxide pigments are reduced with short or long oil reductions, the same conditions hold true. It would become at once apparent, therefore, that if the chalking tendencies of the carbonate pigments are to be overcome and corrected, or the excessive hardness of the oxide pigments is to be reduced, a mixture of the two in the correct proportions should solve the problem. As a matter of fact, mixtures of this type do not become excessively hard, nor do they chalk to any great extent, and, although this principle

was long ago discovered and has been used for years by progressive painters, it must be stated over and over again in order to convince those who are not thoroughly familiar with the results of paint tests.

Conclusions.—After considering the present practice of some of the leading members of the association, and summing up the



Photomicrograph of cross section of paint film. Distinct layers in three-coat work are shown.

results obtained from practical tests made throughout the country, the writer has formed the conclusion that the paint best suited to withstand service is a tinted paint made of a proper mixture of pigments, carefully ground together and applied by a painter, for even the best paint made must be applied by skilful hands, backed by intelligence, if the best results are to be obtained.

FRANKLIN INSTITUTE

(*Proceedings of the Stated Meeting held Wednesday, December 20th, 1911.*)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 20, 1911

PRESIDENT WALTON CLARK *in the Chair.*

Additions to membership since last report, 14.

The following nominations were made for officers and managers, to be voted for at the annual election to be held January 17, 1912:

For President (to serve one year)—Walton Clark.

For Second Vice-President (to serve three years)—James M. Dodge.

For Third Vice-President (to serve two years)—Coleman Sellers, Jr.

For Treasurer (to serve one year)—Cyrus Borgner.

For Managers (to serve three years)—Charles Day, George A. Hoadley, George E. Kirkpatrick, Isaac Norris, Jr., Lawrence T. Paul, James S. Rogers, Otto C. Wolf, and J. J. Gibson.

The Chairman then introduced Dr. Edward L. Nichols, Professor of Physics, Cornell University, who presented an interesting communication on the subject of "Daylight."

The speaker detailed the results of his numerous experiments and investigations made during a period covering several years. He compared daylight at different times of day and at different localities with an acetylene standard, and described the influence of clouds and mist on the quality and quantity of light.

The paper was illustrated by numerous lantern slides of curves plotted from many observations.

In the discussion which followed the reading of the paper, Mr. Shuman, Drs. Barnes, Hoadley, James, Goldsmith, and others participated.

On motion, duly seconded, the thanks of the meeting were extended to Dr. Nichols.

Adjourned.

R. B. OWENS, *Secretary.*

COMMITTEE ON SCIENCE AND THE ARTS.

(*Abstract of Proceedings of the Stated Meeting held Wednesday, December 6, 1911.*)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 6, 1911.

DR. GEORGE A. HOADLEY *in the Chair.*

The following report was presented for final action:

No. 2506.—Sherardizing Metallic Surfaces. Referred back for reconsideration.

The following reports were presented for first reading:

No. 2433.—Cornell Economizer Company's Smoke Prevention. Reported progress.

No. 2499.—Santo Vacuum Cleaner. Reported progress.
No. 2509.—Spangenberg Meter Shelf. Advisory. Adopted.
No. 2510.—Wood's Antifluctuator. Advisory. Adopted.

R. B. OWENS,
Secretary.

SECTIONS.

Section of Physics and Chemistry.—The stated meeting of the Section was held in the Hall of the Institute on Thursday evening, December 14, 1911, at 8 o'clock, with Dr. Robert H. Bradbury, President of the Section, in the Chair. Seventy-three members and visitors were present. The minutes of the previous meeting were read and approved.

Dr. Harry C. Jones, Professor of Physical Chemistry in the Johns Hopkins University, delivered an address on "Recent Developments in the Field of Physical Chemistry, with Special Reference to Solutions." The work of Pfeffer and Van't Hoff on solutions and the dissociation theory of Arrhenius were reviewed. Dr. Jones then discussed his own labors on the occurrence of hydrates and other solvates in solution, and described the methods of studying solvates by means of freezing points, boiling points, and absorption spectra. The lecture was illustrated by means of lantern slides. The paper was discussed by Doctors Williams, Bradbury, and Jones, and Professor Henwood. A vote of thanks was extended to Dr. Jones; the paper was referred for publication, and the meeting adjourned.

JOSEPH S. HEPBURN,
Secretary.

Philadelphia Section, A. I. E. E.—By invitation of the officers and council of the Philadelphia Section of the American Institute of Electrical Engineers, members of the Franklin Institute attended a meeting of the Section on Monday, December 11, 1911, in the Lecture Hall of the Philadelphia Electrical Company.

The paper of the evening, entitled: "A Résumé: Generator and Line Reactance and the Oil Switch," was presented by Mr. A. R. Cheyney.

THE WONDERLAND OF THE SOUTHWEST.

A lecture bearing the above title was delivered in the hall of the Institute on Friday evening, November 24, 1911, by Mr. Frederick Monsen, F.R.G.S., artist and explorer, before a large audience.

The speaker gave an interesting account of his many journeys and explorations in the Southwestern United States during the past twenty-five years. He described the conditions of the Indians of that region at the present time and in the days prior to the discovery of this country, the latter as evidenced by archæological records of ruins and works of art. Numerous anecdotes relating to the inhabitants and incidents of travel held the audience throughout.

The impressive scenery of this comparatively unfrequented land was beautifully depicted in the colored views shown, and to the awe-inspiring grandeur of the cañons of Arizona and Colorado full justice was rendered by the speaker.

MEMBERSHIP NOTES.

Election to Membership.

RESIDENT.

MR. SETH BUNKER CAPP, P.O. Box 2054, Philadelphia, Pa.
MR. JOS. L. E. CHEETHAM, 1922 Shunk St., Philadelphia, Pa.
MR. WM. P. DORNER, 25th Ward Gas Works, Richmond and Tioga Sts., Philadelphia.
MR. HENRY ELFRETH, 1115 Stephen Girard Building, Philadelphia, Pa.
MR. JOHN GRIBBEL, 1513 Race St., Philadelphia, Pa.
MR. ERNEST JOHANSEN, 2117 Master St., Philadelphia, Pa.
MR. CHARLES PENROSE, 1000 Chestnut St., Philadelphia, Pa.
MR. E. L. REYNOLDS, Electric Storage Battery Company, Philadelphia, Pa.
MR. EARL B. SMITH, Drexel Institute, Philadelphia, Pa.

NON-RESIDENT.

ADMIRAL JOHN R. EDWARDS, Post Office Building, Philadelphia, Pa.
MR. FRANK B. GILBRETH, 60 Broadway, New York City.
MR. B. B. MILNER, Pennsylvania Railroad Company, Wilmington, Del.
MR. CALVERT TOWNLEY, Westinghouse Electric Manufacturing Company, 165 Broadway, New York.

ASSOCIATE.

MR. FRANCIS HEED ADLER, 1610 Arch St., Philadelphia, Pa.
MR. EDWIN VON KENNEL BORCHARD, 5042 Walnut St., Philadelphia, Pa.

Changes of Address.

MR. GIDEON BOERICKE, Merion, Pa.
PROF. GEORGE FORBES, 11 Little College St., Westminster, London, S. W., Eng.
MR. J. MCGOWAN, JR., The Robeson, Camden, N. J.
MR. THEODORE H. MORRIS, 1608 Market St., Philadelphia, Pa.
MR. ERNEST STUTZ, 437 Fifth Ave., New York City.

NECROLOGY.

Samuel S. Ash, Swarthmore, Pa.

LIBRARY NOTES.

Purchases.

CHURCH, A. H.—The Proper Distribution of Expense Burden.
KNOEPPEL, C. E.—Maximum Production in Machine Shop and Foundry.

CARPENTER, C. U.—Profit-making in Shop and Factory Management.
CHURCH, A. H.—Production Factors in Cost Accounting.
PRINDEL, E. J.—Patents as a Factor in Manufacturing.
EMERSON, H.—Efficiency as a Basis for Operation.
ARNOLD, H. L.—The Factory Manager and Accountant.
DAY, C.—Industrial Plants.
SCULIER, A. J.—Catalog des Ouvrages Concernant le sucre Bibliotheque. Lewis S. Ware.
West Virginia Geological Survey. Reports. 10 vols.
SHAW, W. N.—Air Currents and the Laws of Ventilation.
BAILEY, B. F.—The Induction Motor.
SHUSTER, A.—The Progress of Physics During 33 Years (1875–1908).
WOLF-CZAPEK, K. W.—Angewandte Photographie in Wissenschaft und Technik.
JONES, B. E.—Hardening and Tempering Steel.
TWELVETREES, W. N.—Reinforced Concrete Beams and Columns.
BRINSMADE, R. B.—Mining Without Timber.
KARAPETOFF, V.—The Magnetic Circuit.
Carnegie Institution. Handbook of Learned Societies. America.
Royal Society of London. Catalogue of Scientific Papers, 1800–1900. Pure Mathematics.

Gifts.

Bologna. R. Accademia delle Scienze, Memoire Serie 7, Tomo 7, 1909–10. Bologna, 1910. (From the Academy.)
Bologna. R. Accademia delle Scienze, Rendiconto delle Sessioni, 1909–1910. Vol. 14. Bologna, 1910. (From the Academy.)
Canada Department of Mines. Summary Report of the Mines Branch for the year 1910. Ottawa, 1911. (From the Department.)
Zi-Ka-Wei Observatoire. Bulletin des Observations, Tome 34, 1908. Fascicule B. Meteorologie. Shanghai, 1911. (From the Observatory.)
Institution of Civil Engineers. Minutes of Proceedings, vol. 185, 1910–11, part 3. London, 1911. (From the Institution.)
Massachusetts Bureau of Statistics. Third Annual Report of the Statistics of Municipal Finances. Boston, 1911. (From R. D. Jenks, Esq.)
Manchester Municipal School of Technology. The Journal, vol. 4, 1910. Manchester, 1911. (From the School.)
National Association of Cotton Manufacturers. Transactions, No. 90, April 12–13, 1911. Boston, 1911. (From the Association.)
Governmental Supervision of Banking Throughout the World. New York, 1911. (From the Girard National Bank.)
Iron and Steel Institute. Carnegie Scholarship Memoirs, vol. 3, 1911. London, 1911. (From the Institute.)
Western Australia Department of Mines. Report for 1910. Perth, 1911. (From the Department.)
Milwaukee City Engineer. Annual Report for the year 1910. Milwaukee, n.d. (From the City Engineer.)

New York Public Service Commission. Annual Report for 1910, vol. 1. Albany, 1911. (From the Commission.)

U. S. Geological Survey. Monograph vol. 52, The Geology of the Lake Superior Region, by Charles R. Van Hise and Charles K. Leith. Professional Paper No. 73, The Tertiary Gravels of the Sierra Nevada of California, by W. Lindgren. Professional Paper No. 75, Geology and Ore Deposits of the Breckenridge District, Colorado, by F. L. Ransome. Washington, 1911. (From the Survey.)

Philadelphia Bureau of Surveys. Annual Report, 1910. Philadelphia, 1911. (From the Bureau.)

London Institution of Mining and Metallurgy. Transactions, vol. 20, 1910–11.

Oklahoma Geological Survey. Bulletin 8, Preliminary Report on the Road Materials and Road Conditions of Oklahoma, by L. C. Snider. Norman, 1911. (From the Survey.)

U. S. Commissioner of Labor. 25th Annual Report, 1910. Industrial Education. Washington, 1911. (From the Department of Commerce and Labor.)

"Underground Jerusalem." Discoveries on the Hill of Ophel, 1909–11. London, 1911. (From the "Field" Office.)

National Electric Light Association. Thirty-fourth Convention, May, 1911. 2 vols. New York, n. d. (From the Association.)

U. S. Library of Congress. Report of the Librarian, 1911. Washington, 1911. (From the Library.)

U. S. Civil Service Commission. Twenty-Seventh Annual Report, 1910. Washington, 1911. (From the Commission.)

Scotland Institution of Engineers and Ship-builders. Transactions, vol. 54, 1910–11. Glasgow, 1911. (From the Institution.)

British India Forest Administration, Review for the year 1909–10. Simla, 1911. (From the Administration.)

BOOK NOTICES.

ANNUAL TABLES OF CONSTANTS AND DATA, Chemical, Physical and Technological.

The first volume of the above work, which has been compiled by an International Commission appointed by the Seventh International Congress of Applied Chemistry, will shortly appear from the press.

The Tables will form a volume of about 400 pages and will cover a wide range of scientific and technical literature collected from more than 300 periodicals on chemistry, physics, and allied sciences.

The terms of subscription and descriptive leaflets may be obtained from any one of the three American Commissioners: Dr. G. N. Lewis, the Massachusetts Institute of Technology, Boston, Mass.; Prof. C. F. Hull, Dartmouth College, Hanover, N. H., and Prof. J. Stieglitz, the University of Chicago, Chicago, Ill.

It is announced that the price of the volume may be advanced about January 15.

PUBLICATIONS RECEIVED.

Portland Cement: Its Composition, Raw Materials, Manufacture, Testing and Analysis. By Richard K. Meade, M.S. Second edition. 512 pages, illustrations, plates, 8vo. Easton, Pa., Chemical Publishing Company, 1911. Price, $4.50.

Fertility and Fertilizer Hints. By James Edward Halligan. 155 pages, illustrations. 8vo. Easton, Pa., Chemical Publishing Company, 1911. Price, $1.25.

A brief Laboratory Guide for Qualitative Analysis. By Arthur E. Hill, Ph.D. 80 pages, 12mo. Easton, Pa., Chemical Publishing Company, 1911. Price, $1.00.

Quantitative Chemical Analysis Adapted for Use in the Laboratories of Colleges and Schools. By Frank Clowes, D.Sc., and J. Bernard Coleman, A.R.C.Sc. Ninth edition. 565 pages, illustrations, 8vo. Philadelphia, P. Blakiston's Son & Co., 1911. Price, $3.50.

Ueber gerichtete drahtlose Telegraphie mit Erdströmen von L. Zehnder. Sonder-Abdruck aus den Verhandlungen der Deutschen Physikalischen Gesselschaft. xiii Jahrgang Nr. 21. 2 pages, illustrations, 8vo. Braunschweig, Fr. Vieweg & Sohn, 1911.

Beruht die drahtlose Telegraphie auf der Ausstrahlung Hertzscher Wellen in der Erde von L. Zehnder. Sonder-Abdruck aus der Elektrotechnischen Zeitschrift, 1911. Heft 44. 5 pages, 8vo. Berlin, Julius Springer.

Factories and Warehouses of Concrete. 223 pages, illustrations, 8vo. Philadelphia, Association of American Portland Cement Manufacturers, 1911. Price, 50 cents.

ENGINEERING AND TECHNICAL SOCIETIES.

Directory and Meetings.

American Association for the Advancement of Science, Mr. L. O. Howard, Secretary, Smithsonian Institution, Washington, D. C.—Annual meeting, December.

American Electric Railway Association, Mr. H. C. Donecker, Secretary, 29 West 39th Street, New York, N. Y.—Annual movable convention. Mid-year conference, New York.

American Electrochemical Society, Dr. J. W. Richards, Secretary, South Bethlehem, Pa.—General meeting, April.

American Foundrymen's Association, Mr. Richard Moldenke, Secretary, Watchung, N. J.—Convention, Buffalo, June 4, 5 and 6, 1912.

American Institute of Chemical Engineers, Mr. John C. Olsen, Secretary, Polytechnic Institute, Brooklyn, N. Y.—Annual meeting, December.

American Institute of Electrical Engineers, Mr. F. L. Hutchinson, Acting Secretary, 33 West 39th Street, New York, N. Y.—Monthly meetings, second Friday. Panama Trip, January 17, 1912.

American Institute of Mining Engineers, Mr. Rossiter W. Raymond, Secretary, 29 West 39th Street, New York, N. Y.

American Iron and Steel Institute, Mr. W. J. Filbert, Secretary, 30 Church Street, New York, N. Y.

American Mathematical Society, Mr. F. N. Cole, Secretary, 30 West 116th Street, New York, N. Y.—Annual meeting, December. Regular meetings, February 4, April 7, October 6, 1912. Columbia University.

American Philosophical Society, Secretaries, 104 South 5th Street, Philadelphia.

American Physical Society, Mr. Ernest Merritt, Secretary, Cornell University, Ithaca, N. Y.—Annual meeting, December.

American Railway Master Mechanics' Association, Mr. J. W. Taylor, Secretary, Old Colony Building, Chicago, Ill.

American Society of Chemical Engineers, Mr. John C. Olsen, Secretary, American Society of Chemical Engineers, Polytechnic Institute, Brooklyn, N. Y.—Annual meeting, December.

American Society of Civil Engineers, Mr. Charles Warren Hunt, Secretary, New York, N. Y.—Annual meeting, New York, January 17 and 18, 1912. Meetings, first and third Wednesdays, except June, July, and August.

American Society of Mechanical Engineers, Mr. Calvin W. Rice, Secretary, New York, N. Y.—Annual meeting, December.

American Society of Municipal Improvements, Mr. A. P. Folwell, Secretary, 239 West 39th Street, New York, N. Y.—Annual meeting, Dallas, Tex., November 12–15, 1912.

American Society for Testing Materials, Dr. Edgar Marburg, Secretary, University of Pennsylvania, Philadelphia.—Annual meeting.

Association of Engineering Societies, Mr. Fred. Brooks, Secretary, 31 Mills Street, Boston, Mass.—No meetings.

Canadian Electrical Association, Mr. T. S. Young, Secretary, Toronto, Canada.

Engineers' Club of Philadelphia, Mr. W. P. Taylor, Secretary, Philadelphia.—Meetings, first and third Saturdays, except last in June to first in September.

Engineers' Society of Western Pennsylvania, Mr. Elmer K. Hiles, Secretary, 2511 Oliver Building, Pittsburgh, Pa.—Mechanical Section meets bi-monthly.

Illuminating Engineering Society, Mr. Preston S. Millar, Secretary, New York, N. Y.

Master Car Builders' Association, Mr. J. W. Taylor, Secretary, 390 Old Colony Building, Chicago, Ill.—Annual meeting.

National Academy of Sciences, Mr. Arnold Hague, Secretary, U. S. Geological Survey, Washington, D. C.

National Association of Cotton Manufacturers, Mr. C. J. H. Woodbury, Secretary, Boston, Mass.—Meets April and December.

National Electric Light Association, Mr. T. C. Martin, Secretary, 33 West 39th Street, New York, N. Y.—Annual convention, Seattle, June.

Railway Signal Association, Mr. C. C. Rosenberg, Secretary, Bethlehem, Pa.—Meetings, Chicago, March 18, 1912; New York, June 11, 1912. Annual movable convention, October 8, 1912.

Society of Automobile Engineers, Coker F. Clarkson, General Manager, 1451 Broadway, New York, N. Y.—Annual meeting, New York, January 18–20, 1912.

Society for the Promotion of Engineering Education, Prof. H. H. Norris, Secretary, Cornell University, Ithaca, N. Y.

Western Society of Engineers, Mr. J. H. Warder, Secretary, 1735 Monadnock Block, Chicago, Ill.—Annual meeting, January 10, 1912. Monthly meetings, first Wednesday, except January, July, and August. Section meetings, other Wednesdays, except July and August.

CURRENT TOPICS

Dr. Alex. C. Humphreys and the American Society of Mechanical Engineers.—Before a great assemblage of prominent engineers, Dr. Alex. C. Humphreys, already eminent as president of Stevens Institute, and as one of the foremost gas plant engineers in this country, was installed on December 5, 1911, as president of the American Society of Mechanical Engineers.

Dr. Humphreys has been a member of the Franklin Institute since 1889, and is also a member of its Committee on Science and the Arts.

Alloys of Cobalt with Chromium. E. HAYNES. (*Jour. Ind. and Eng. Chem.*, ii, 397.)—The color of the cobalt-chromium alloys is between that of steel and silver. These alloys have a remarkable resistance to corrosion, only equalled by gold and the platinum metals. Nitric acid and solutions of caustic alkalies have no action on some of these alloys, which are likewise impervious to all atmospheric influences. On heating in air they retain their color up to 500° C., when a faint straw color is apparent, which deepens as the temperature rises. No scale is formed even when heated to bright orange. Various suggestions are made as to the uses to which these alloys can be applied.

Electronic Charge. J. ROUX. (*Comptes Rendus*, clii, 1168.)—By the pulverization of liquid sulphur spherical charged particles are obtained. These particles solidify without crystallizing, and, like Millikan's, can be followed for several hours in a microscope, slowly descending by gravitation, rising in an electric field and sometimes suddenly parting with an electron under the observer's eyes. In applying Stokes's law, Millikan assumes that there is no recoil of the air particles from the droplets. But that is an improbable assumption. If there is elastic recoil the numerical coefficient will be doubled and the electronic charge, instead of being 4.9×10^{-10}, will be 4.4×10^{-10}. Observations on sulphur drops lead to the value of 4.17×10^{-10}, which is close to the value obtained from Brownian motions.

Use of Radio-Activity in Brewing. W. CASPARY. (*Allg. Brauer u. Hopfen Zeit.*, 1911, 1647.)—Recent investigations have shown that radio-active emanation has an important influence on the growth and function of yeast. The application of this to the

production of uniform, strongly aromatic, and palatable beers is proposed. One or more cylinders containing emanation are lowered into the wort during fermentation. Storage casks are similarly provided, the development of aroma during after-fermentation being improved thereby.

The Structure of Galvanized Iron. W. GUERTLER. (*Int. Z. Metallog.*, i, 353.)—Iron is coated with zinc (1) by dipping in molten zinc, (2) by immersing in zinc dust and heating (Sherardizing), and (3) electrolytically. In the first two processes, the zinc immediately in contact with the iron combines to form a layer of crystals of the composition $FeZn_3$. The electrolytic process also gives rise to an intermediate layer, but small in amount, and its nature is not definitely known. The compound, $FeZn_3$, is electronegative to both zinc and iron, and, therefore, when it becomes exposed, by the removal of the outer coating of zinc, it accelerates corrosion at the expense of both metals. The zinc coating obtained by dipping always shows some included crystals, approximately $FeZn_7$, which are also electronegative to zinc and accelerate the corrosion of the zinc coating. The zinc coatings obtained by Sherardizing and electrolytically are porous. No one of the three processes can be considered as having any marked superiority.

Syrian Self-burning Limestone. ANON. (*Oil, Paint, and Drug Reporter*, August 7, 1911.)—The United States Consul at Jerusalem states that while making a trip through the Hauran he was shown a curious stone which might be considered a self-burning limestone. The rock lay in a stratum between ordinary limestone; was of a grayish-black color, and had an odor of petroleum when freshly broken. It is easy to quarry, as the rock is soft and full of seams. The stone is broken into small pieces and burned in a clamp. After about twelve hours the stone is converted into lime. The lime is white, and is said to make a very strong plaster, but sells at a low figure because of the low cost of production.

Manufacture of Dynamos. ANON. (*Amer. Mach.*, xxxv, 13, 594.)—The most important generic group of electrical machinery includes dynamos, dynamotors, motor generators, and similar machines. The number of dynamos manufactured annually increased from 10,527 in 1899 to 15,080 in 1904 and 16,791 in 1909, an increase of 59 per cent. for the decade. The values for each year respectively were $10,473,000, $11,084,000, and $13,081,000. As a rule much larger and more powerful dynamos were manufactured in 1909 than in the previous years so that, while the average value of machines manufactured was greater in 1909, they represented a lower cost for corresponding capacity. The average capacity per machine increased from 55 kilowatts in 1899 to 66 in 1904 and 84 in 1909.

Automobile Exports. ANON. (*Amer. Mach.*, xxxv, 15, 702.)—Canada is by far the largest market for automobiles exported from the United States. Of approximately 9,000 machines exported in the seven months ended with July, 1911, 3,724 went to Canada, 1,875 to the United Kingdom, 983 to British Oceania (chiefly to Australia and New Zealand), 477 to Asia and non-British Oceania, 444 to South America, 273 to France, 175 to the West Indies and Bermuda, 147 to Mexico, 137 to Italy, and 73 to Germany. These figures do not include the shipments to non-contiguous territory of the United States, the number sent to Hawaii was 202, to Porto Rico 154, and to Alaska 2.

Tantalum for Standard Weights. COMITÉ INTERNAT. DES POIDS ET MÉSURES. (*Procès Verbaux des Séances*, ii, 6; *Nature*, Aug. 24, 1911, 251.)—Owing to the high price of platinum a suitable substitute has been sought for the construction of standard weights. Tantalum, which resists all mineral acids except hydrofluoric acid, is found to have the necessary permanence and hardness, and it is suggested that a series of standard weights of 100 grammes, made of tantalum, should be established for use in chemical research. The cost would, probably, not exceed one-third of that of iridio-platinum weights.

Monazite Sand from Travancore, India. ANON. (*Bull. Imp. Inst.*, ix, 103.)—A considerably extensive deposit of naturally concentrated monazite sand has been discovered near Quilon, Travancore, India. This sand contains 4 per cent. of thoria, and consists of from 46 to 50 per cent. of monazite, with ilmenite and zircon as the other chief constituents, together with some rutile and traces of spinel, garnet, quartz, and hornblende. A specimen of pure monazite separated from the sand contained 8.5 per cent. thoria. The monazite can be concentrated by an electro-magnet. A specially-prepared concentrate contained 8.87 per cent. thoria, and pure monazite separated from this contained 10.08 per cent. of thoria. The commercial concentrate contains 5 to 6 per cent. thoria, as compared with less than 4 per cent. in the Brazilian sand, and the pure monazite from the Travancore deposit is richer than that from the Brazilian and Carolina deposits, resembling the monazite from Ceylon.

Paper as a Substitute for Goldbeaters' Skin. W. THEOBALD. (*Papier-fabrikant*, ix, 983.)—Many attempts have been made to introduce paper as a substitute for the costly prepared skins used by goldbeaters, but only with partial success. Paper was employed before goldbeaters' skin for making leaf metals, and the Chinese and Japanese still use paper, made from the fibres of the mulberry tree for goldbeating. For the first stages of goldbeating,

animal parchment has been used since the seventeenth century; also vegetable parchment in the later stages. Comparative experiments have shown that animal parchment permits only a relatively very slight reduction of the metal sheet; parchment paper allows the metal to be beaten somewhat thinner, but when the limit is passed the metal adheres so firmly to the paper that it cannot be separated without damage. According to a process devised by J. Heinrich (Ger. Pat. 123,197), thin, tough paper of substance of 25 to 30 grammes per square metre is steeped in a hot solution of borax or alum. The paper is stretched over frames, and a coating, first of albumin and then of isinglass solution, is applied, first to one side and then to the other. Papers of various kinds are now used in many goldbeaters' shops, but only for the first stages; the leaf metal is always finished between ordinary goldbeaters' skin. Leaf made from baser metals, however, is beaten throughout between paper. A papr which will serve all the purposes of skin for the manufacture of gold-leaf has yet to be discovered.

Corrosion of Iron Machinery. ANON. (*Sci. Amer.*, civ., 21, 549.)—Warner and Davey, in England, have investigated the corrosion observed in iron machinery used in certain industries, especially in the production of illuminating gas. No serious corrosion is caused by the cold ammoniacal liquors, but the tar may corrode the distilling tubes. This is chiefly due to the presence, in the tar, of ammonium chloride, sulphide, and cyanide, which are dissociated at a high temperature. The parts of the tubes that are most rapidly corroded are those which are subjected to irregular deformation from alternate expansion and contraction due to changes of temperature.

The New Armor Plate. ANON. (*Sci. Amer.*, civ, 24, 612.)—The Simpson armor plate, of which so much is heard to-day, is broadly similar to the old compound armor plate, which was made by welding a hard steel face upon a soft steel or iron backing. This armor was imperfect, the face breaking away from the backing when struck by a projectile. Simpson secures a bond by welding a thin plate of copper between the two layers of steel. A superiority of 25 per cent. is claimed over Krupp armor. This is due to the fact that the face of hard steel that can be welded on by this process is much thicker than that which can be welded on by the old method.

Silica Glass. ANON. (*Sci. Amer.*, civ, 14, 367.)—Such extensive use has been made during the past few years of silica glass for chemical apparatus that it became necessary to devise a method whereby this glass might be produced in the electric furnace instead of by the oxyhydrogen blowpipe. To produce perfectly transparent

silica glass from melted quartz an artifice is required, because on reaching the temperature of 600° C. the quartz splits and minute bubbles of air fill the mass. This can be prevented by first raising the temperature of the quartz to a point little under 600°, and then surrounding it with liquid silica at a temperature of 2000° C. The liquid silica acts as a shield to prevent the entrance of air when the quartz splits, and thus the formation of bubbles is avoided.

Artificial Leather. ANON. (*Sci. Amer.*, civ, 21, 549.)—The price of leather is rising rapidly, and several inventors are endeavoring to produce satisfactory substitutes for this material. M. Louis Gevaert, of Beveren-les-Audenarde, has been so remarkably successful in his efforts that he was awarded a prize of 5,000 francs by an Agricultural Committee of Terni. The process was patented in 1907 and perfected by successive steps. It consists of the more or less intimate impregnation of stout cotton cloth with tannic albuminoid substances. Shoes made of this are said to possess not only the resistance and elasticity of natural leather, but also its durability of wear. They are much cheaper than leather, costing, including manufacture, only about four francs and selling for about six francs per pair.

Electricity in Indian Mills. ANON. (*Sci. Amer.*, civ, 14, 365.)—The mills in Bombay are largely driven by steam power at present, and this proves to be very costly. A scheme has been started to generate the power required from stored water. During the monsoon water is to be collected and stored in large reservoirs up in the ghats about forty miles from Bombay. The valleys which are being dammed are close to a fall of 1,740 feet, and it is the power of this fall which is to be utilized. The transmission line to Bombay is about forty-three miles long, and a voltage of 80,000 will be used in the line. In Bombay it will be transformed to varying voltages for distribution to consumers, which will be principally the cotton mills. These mills alone now use about 100,000 horse-power.

Absorption of Hydrogen by Tantalum and Tungsten. A. SIEVERTS and E. BERGNER. (*Ber.* xliv, 2394.)—The solubility of hydrogen and nitrogen in tantalum up to 1330° C. has been measured. At constant pressure the solubility decreases as the temperature rises, and at constant temperature is proportional to the square root of the pressure. Heating in hydrogen causes a structural change in the metal, which becomes brittle and crystalline. The original condition is not restored by removing the hydrogen, but only by heating nearly to the melting point. Tantalum reacts slowly with nitrogen above 900° C., forming a nitride. Tungsten dissolves very little hydrogen and does not react with nitrogen at any temperature up to 1500° C.

Heat of the Evaporation of Oxygen. HERMANN BARSCHALL. (*Zeit. Elektrochemie*, xvii, 345.)—The experiments were conducted by Estreicher's method, by passing a measured amount of electrical energy through a small resistance coil suspended in the liquid oxygen, and measuring the volume of the resultant gaseous oxygen. Special precautions were taken to prevent the introduction of heat other than that supplied by the current. The mean of six determinations is 51.3 calories per gramme at 760 millimetres pressure.

Application of Electricity in the Metallurgical Industry of Italy. R. CATANI. (*Iron and Steel Inst.*, October, 1911.)—Stassano's experiments on the production of steel directly from the ore are described, with full details of the composition of the ore, charcoal, and flux used. A steel containing 0.1 per cent. each of carbon, manganese, and silicon was obtained with a consumption of 4187 kilowatt-hours per ton. In later trials an ore containing 48.09 per cent. of iron was crushed and briquetted with 25 per cent. sodium silicate, and from this a steel was produced containing 0.26 per cent. carbon, 0.21 of manganese, 0.03 of silicon, 0.01 of phosphorus, and 0.04 of sulphur, with a consumption of 4250 kilowatt-hours per ton. A description is given of the production of steels from scrap iron, ferrosilicon and ferromanganese in various types of furnace, with a tabulated statement of the composition of the materials and the steel. Working with a liquid steel from a 4-ton open-hearth furnace, containing 0.08 per cent. of carbon, 0.03 of silicon, and 0.08 of manganese, and recarburizing with pig iron, a steel containing 0.6 per cent. of carbon, 0.025 per cent. of silicon, and 0.12 of manganese was obtained. Carcano, working with powdered pyrites residues, containing 47.0 per cent. of iron, 12.25 of silicon, 18.8 of aluminum, and 2.6 of sulphur, and with a basic slag, produced an iron containing 0.058 per cent. of sulphur, 0.075 of phosphorus, 2.17 of manganese, and 4.46 of silicon. There were 628 tons of ferrosilicon manufactured in 1909. By using an iron silicate ore and quartz, alloys containing up to 25 per cent. of silicon were produced. By using 1300 kilos of an ore containing 75.5 per cent. of ferrous oxide and 9 of silica, with 2330 kilos of quartz and 1000 kilos of coke, an alloy containing 40 per cent. of silicon was produced.

Diamonds and Platinum in British Columbia. (*Rept. of Geol. Survey of Canada*, 1910.)—Diamonds have recently been discovered in a sample of chromite taken from the peridot of Olivine Mountain, about seven miles west of Tulameen Village, British Columbia. This is the first recorded discovery of diamonds in Canada, either in solid rock or in placer. In one large sample of rock which was worked down for diamonds, one or two particles of native gold and several particles of native platinum were found accompanying the diamond residuum. Results obtained in a search for the original

source of the platinum of the Tulameen district showed that this mineral was often found in appreciable quantity with the chromite, sometimes as much as half an ounce to the ton. The chromite segregations are too small and too far apart to make the extraction of platinum commercially profitable. The gold is in even smaller quantity than the platinum. Part of the chromite is magnetic and part non-magnetic.

Concentration and Isolation of Radioactive Substances by Fractional Adsorption. E. EBLER and M. FELLNER. (*Ber.*, xliv, 2332.)—The adsorption of radioactive substances in solution by means of gelatinous silicic acid is suggested as a suitable process for their fractional separation or isolation. The substance is shaken with a convenient quantity of water and silicic acid in a sealed glass tube for some time, raising the temperature if necessary. The silicic acid gel is then separated by filtration or with a centrifuge. The silicic acid is then volatilized as silicon fluoride, leaving the adsorbed substance as a residue. In a series of experiments with barium-radium chloride, the activity of the adsorbed portion was from 11 to 35 times that of the non-adsorbed portion. Solutions containing radio-lead and uranium X gave equally satisfactory results.

Aluminum-Zinc Alloys. A. PORTEVIN. (*Rev. Mét.*, viii, 721.)—Ten alloys of zinc and aluminum, increasing by steps of 10 per cent. of aluminum, were cast in sand, and the results of the mechanical tests, elasticity, hardness, shearing strain, and the thermo-electromotive force against copper, are tabulated and curves given. The tensile strength reaches a maximum at 60 per cent. of aluminum corresponding to the limit of solid solution; the Brinell hardness test shows a similar maximum at 60 per cent. aluminum, and a second, less marked one, between 10 and 30 per cent. The thermoelectric force increases with the content of aluminum. The alloys were forged and then annealed for one hour at 300° C. Forging very greatly increases the tensile strength and elongation, while annealing decreases these properties, the yield point being greatly lowered.

Incandescence Mantles made from Artificial Silk. NASS. (*J. Gasbeleucht*, liv, 938.)—Mantles made from continuous fibres of artificial silk are now purchasable. Microphotographs show that the fibres remain distinct and unbroken while in use, whilst the short fibres in mantles made from cotton or ramie untwist more or less from the original structure of the spun yarn. Hence mantles made from artificial silk are the strongest and most durable. When tested on Drehschmidt's machine, which subjects the mantle to a recorded number of shocks, a good ramie mantle will endure from 500 to 1,000 shocks when new, but only 100 after ten hours' use. Artificial silk mantles will endure 6,000 shocks when new, and

will support a suspended weight of 20 grammes; after 500 hours' use they will support 15 grammes. An artificial silk mantle lasted seven weeks on a high-pressure burner on which a ramie mantle lasted only six days.

Prevention of the Contamination of Water Supplies by Waste Lyes from Sulphite-Cellulose Works. B. REINITZER. (*Z. Angew. Chem.*, xxiv, 1851.)—It is stated that by mixing together the waste digestion liquors and the residues from the bleaching process both waste products are rendered harmless to fish, and can be safely discharged into water courses. This method is said to have worked satisfactorily in actual practice for a long time.

Production of Potassium Salts from Feldspar. ANON. (*Sci. Amer.*, cv, 7, 136.)—All the potassium salts required for manufacturing fertilizer in the United States are now imported from Germany, at a cost last year of $8,000,000. Yet there are enormous quantities of potassium in the States in the form of feldspar rock. By slow weathering of this rock part of the potassium is made available for plant use in a soluble form. But this element is removed by the crops faster than it is produced. A process has been developed, by heating finely-ground feldspar (potassium aluminum silicate) with calcium chloride and limestone, by which the potassium can be recovered as soluble potassium chloride. The residue can be calcined to form cement. One ton of feldspar rock may yield 190 pounds of potassium chloride and five or six barrels of cement. At present this process is too costly to work, but the probabilities are that the problem will be solved commercially before long.

The Ivory Supply. ANON. (*Sci. Amer.*, cv, 7, 160.)—Owing to the rapid disappearance of the herds of elephants formerly found in Africa, and the limited number now remaining in Asia, the ivory supply is becoming scarce. Attention is therefore called to the enormous supply of ivory existing in the frozen tundras of Siberia, which will probably suffice for the world's consumption for many years. This ivory consists of the tusks of the extinct species of elephant called mammoths. These tusks are of great size and they are very abundant at some places in Siberia, where the frost has perfectly preserved them.

Synthetic Rubber. ANON. (*Sci. Amer. Suppl.*, 1859, 115.)—The *Journal of the Royal Society of Arts* says it will be a long time before synthetic rubber seriously affects the price of rubber, but that period must be expected. Dr. Gerlach has recently spoken on this point before the German Rubber Commission, and his views are worth noting. At the beginning of his investigations Dr. Gerlach was sceptical as to its value, and was much surprised when

bulk samples satisfied him that synthetic rubber possesses the essential properties of high-grade material. The raw material of synthetic rubber is a manufactured article, but there is little doubt that synthetic rubber will eventually appear on the market as a commercial product. However, producing costs will have to be materially reduced before serious competition with natural rubber is possible.

Photographs in Railway Work. ANON. (*Sci. Amer.*, CV, 7, 155.)—Photography has been substituted for written reports on construction work on a Western railroad. The progress of the work of changing a grade crossing or building a bridge is photographed at stated intervals, and the photographs are preserved as a record and as illustrations of the method. Pictures are taken of all the "material" of the road, and of every mile of track, showing curves, grades, switches, and crossings. The book of rules, which is in the hands of every railroad man, is illustrated by a complete set of photographs; this enables the men to refresh their memories as to any particular point on the road, and thus makes them readily interchangeable from one division to another. Trains, too, are photographed in more than one hundred combinations of circumstances, and the text instructs the trainmen what to do in each case.

Methyl Alcohol in the United States. ANON. (*Chemist and Druggist*, August 26, 1911.)—Crude methyl alcohol is usually termed "wood alcohol" in commerce, and because of the word "alcohol" in the name many ignorant people think it is a cheap grade of ordinary alcohol, and have purchased it for potable purposes, especially in prohibition sections. The results have frequently been fatal, and in other cases have caused a temporary or a permanent blindness, due to paralysis of the optic nerve. Hence the enactment of a law in Minnesota last year providing that methyl alcohol must be called "wood naphtha" in trade, and must be so named in catalogues and on labels. It is hoped that in this way the laity will become unfamiliar with the term "wood alcohol" and will not fall into the error of assuming that "wood naphtha" is a beverage. The New York State Pharmaceutical Association, at its recent annual meeting, agreed to endeavor to promote similar legislation, and the National Association of Retail Druggists believes that a national law on these lines should be enacted.

Bologna Luminous Stones. L. VANINO and E. ZUMBUSCH. (*J. Prakt. Chem.*, lxxxiv, 305.)—Bologna stones possessing the phosphorescent quality contain from 12 to 33 per cent. of sulphur; the presence of polysulphides is generally accompanied by marked phosphorescent power, but stones containing monosulphide only are deficient in phosphorescence. The proportion of sulphur in polysul-

phide is, at the most, about 2.5 per cent., and material containing only monosulphide is considerably improved by the addition of calcium oxide. Starch, up to 4 per cent., increases phosphorescence, but a larger proportion diminishes phosphorescence. The period of photo-chemical induction requisite for exciting maximum phosphorescence is shorter for stones of comparatively simple composition and high metal content than for those of more complex composition and low metal content, and the rate of decay is correspondingly less in the latter. Confinement in various gases—*e.g.*, chlorine, ammonia, and hydrogen sulphide—and mixing with organic dyestuffs or other so-called optical sensitizers, does not increase the phophorescence. Pressure is distinctly unfavorable; grinding causes a change of color and reduces phosphorescence. Exposure to light also changes the color to an extent dependent on the composition of the stone; but there is no apparent connection between the phosphorescent power and the readiness with which the color changes.

Colloidal Sulphur. M. RAFFO and J. MANCINI. (*Z. Chem. Ind. Kolloide*, ix, 58.)—The stability of the colloidal sulphur solution prepared by one of the authors was due to the presence of sulphuric acid and sodium sulphate. Further experiments have now shown that the greatest stability is reached when the solution contains definite proportions of these substances, viz., 6.4 to 7.0 per cent. of sulphuric acid and 3.76 to 3.93 per cent. of sodium sulphate; the solutions contained 2.6 to 2.8 per cent. of sulphur. Coagulation experiments with salts of potassium, sodium, magnesium, zinc, aluminum, and chromium showed that potassium salts coagulate the colloidal sulphur much more readily than salts of other metals, and the iodides are the most effective of the alkali salts. 4N solutions of sodium salts precipitated approximately twice as much sulphur as 2N solutions did.

Heat Treatment of Steel. H. HANEMAN. (*Stahl und Eisen*, xxxi, 1365.)—Pieces of steel wire, 0.5 cm. in diameter and 20 cm. long, containing from 0.99 to 1.56 per cent. of carbon, were heated to temperatures varying from 750° C. to 1150° C. and quenched, either in water or in a lead-tin bath, at 300° C. Quenching at the higher temperature gave the highest tenacity. The tabulated results of the mechanical tests of hardened steels, after tempering in rape oil at temperatures from 100° C. to 650° C., show that it is not possible to obtain the same results by direct quenching in oil or in a lead-tin bath as by quenching in water and subsequently tempering. To determine the influence of time on tempering—*i.e.*, whether heating at 500° C. for a few seconds would produce the same structure as heating at 100° C. for many hours—pieces of steel containing 0.87 per cent. of carbon were heated to varying temperatures for different periods of time, and then examined for

scratch hardness, loss of weight in a 1 per cent. acid solution, the amount of carbide, and microscopically. It is concluded that hardened steel always tends to change into α-iron and free cementite. Although this change proceeds imperceptibly at ordinary temperatures, it takes only a few seconds at 650° C. and some hours at 100° C.

Silver, Tin, Lead: the Ternary System. N. PARRAVANO. (*Gaz. Chim. Ital.*, xli, 813.)—This paper is a thermal and microscopic study of ternary alloys of silver, tin, and lead. All the ternary alloys are composed of the four solid phases, mixed crystals of silver and tin, mixed crystals of lead and tin, the compound Ag_3Sn, and crystals of tin. The system contains two non-variant points, one of which, at about 300° C., is a transformation point, while the other, at about 175° C., is an eutectic point. The ternary eutectic contains 63.4 per cent. of tin, 35.6 per cent. of lead, and 1 per cent. of silver. The transformation point is very near the binary lead-silver eutectic point, and the ternary eutectic point is very near the binary tin-lead eutectic point. This paper has 23 microphotographs.

Paper Pulp from Eucalyptus. ANON. (*Paper Making*, xxx, 376.)—Samples of pulp of excellent quality have been prepared from the eucalyptus (blue gum) which has been planted over large areas in Southern California. The pulp is strong, clean, and slightly reddish, owing to the action of the alkali. Experiments with this wood as a raw material for paper pulp have been carried out at Washington and leave no doubt that it is suitable for the purpose. A sufficient growth of blue gum may be obtained in four to six years; three years after cutting the stump yields a further good growth.

Preservative Treatment of Poles. W. H. KEMPFER. (*Forest Service Bull.*, 84, 1911.)—As the pressure method of treatment with creosote is comparatively costly, investigations were directed to simpler and cheaper methods, which could be employed locally. Special attention was given to the seasoning of the timber, and investigations were conducted with the object of (1) testing the efficiency of various wood preservatives and of the application of varying amounts; (2) developing a method for impregnating the butt, as the portion of the pole most subject to decay; (3) designing inexpensive apparatus for local use in application. The timbers used were chestnut, three kinds of cedar, and three kinds of pine; and six different commercial preservatives were tried. The conclusions reached were: The reduction in the weight of poles by seasoning is generally from 16 to 30 per cent., and thorough seasoning is an essential preliminary to preservative treatment. Poles cut during autumn and winter lose weight less rapidly but more

regularly than those cut during the spring and summer; the shrinkage during seasoning does not exceed 1 per cent. on the circumference; too rapid seasoning may be detrimental to the timber by causing excessive "checking." The superficial application of a preservative, by a brush, to the butt of a pole is not as effective as actual impregnation of the wood, but generally adds two or three years to the life of the pole. Impregnation of many pole timbers may be successfully accomplished by simple immersion in open tanks, first in the hot and then in the cold preservative; as this process may be applied to the butts only, a great saving of preservative is effected.

Production of Molybdenum Steel in the Electric Furnace. E. T. DITTUS and R. G. BOWMAN. (*Met. and Chem. Eng.*, ix, 531.)—The authors give the results of laboratory experiments, mostly qualitative, on the direct production of molybdenum steel by the simultaneous reduction of hæmatite iron ore and molybdenite. The iron ore was reduced by coke, using ferrosilicon as the desulphurizing agent. The electric furnace could be used either on the Héroult or the Girod principle. The conclusions are that molybdenum steel, low in sulphur, can be made in this manner, and that the molybdenite may be added in the form of low-grade concentrates. The Girod type of furnace is preferable to the Héroult, but the furnace should be of the tilting type, to facilitate the tapping of the metal.

The Cementation of Iron by Solid Carbon. G. CHARPY and S. BONNEROT. (*Rev. Scient.*, xlix, 17, 539.)—The contradiction in the results given by different experimenters, such as Guillet and Griffith, Weyl and others, on the subject of the cementation of iron by solid carbon, is due to the fact that the atmospheres in which the operation took place were not well defined, either as to composition or as to pressure. New experiments, where minute precautions were taken to avoid these sources of error, have shown that there is absolutely no cementation of iron by solid carbon at about 950° C., when there is no gas present which can react with the carbon or the metal.

Helicoidal Crystals. P. GAUBERT. (*Rev. Scient.*, xlix, 17, 540.)—The new form of crystal, the helicoidal, which M. Wallerant obtained by melting on a plate of glass certain substances mixed with a body possessing rotatory power, has also been obtained by evaporating a solution. This in the case with phthalic acid mixed with a solution of physotigmine. However, methylene blue, which has a strong influence on the dominant form of crystals, will not produce the helicoidal form. Sulphurated urea will give the helicoidal form when it is slightly decomposed by boiling; at first it forms spherolites with a helicoidal outline, and finally ordinary crystals.

Nature of Volcanic Action. R. A. DALY. (*Amer. Acad. Proc.*, xlvii, No. 3, 47.)—An hypothesis is outlined on the assumption that the earth is exteriorly composed of successive shells, of a density increasing with depth. Beneath the interrupted sedimentary shell is a continuous solid "granitic" shell, and below that an eruptive basaltic shell, or substratum. It is assumed that all igneous action, since an early pre-Cambrian period, is the result of the mechanical intrusion of the substratum basalt into the overlying shell by abyssal injection. Dealing mainly with central eruptions as distinct from fissure eruptions, they are classified into two main groups: (*a*) Principal, where each vent represents emanation from a main abyssal injection; (*b*) subordinate, where each vent originates over a magmatic body in the form of a laccolith, sheet, etc., which is satellitic with respect to a main abyssal injection. Principal volcanoes will be more active, of longer duration, more productive of lava flows, and more clearly related to crustal fissures. Kilauea may be considered a subordinate volcano. The local occurrence of steam is not regarded as a primary cause of explosion; the energy producing explosion is more probably derived from deep-seated heated magma.

Increasing the Catalytic Action of Iron Salts. J. WOLFF and E. DE STOECKLIN. (*Mon. Sci.*, 838, 697.)—The conclusions of this article are: (1) If any iron salt, such as the nitrate, sulphate, chloride, or acetate, has any catalytic action alone, this action is markedly increased by adding small quantities of an alkaline sulphocyanide; (2) this activity is greatly increased by adding small, increasing quantities of the salt; (3) at the moment the two salts are in such proportion that their combination is represented by the formula $(CNS)_6K_4Fe$ the activity has reached its maximum; (4) as soon as the maximum is reached, a large excess of potassium sulphocyanide does not sensibly increase the reaction.

Liquid Mixtures for Laying Coal-dust. W. M. THORNTON. (*Mech. Eng.*, xxviii, 210.)—The reason that water alone does not wet the coal-dust may be due to the oily components of the dust and the high surface tension of the water. In laboratory experiments various soap solutions were tried. Solutions of 5 per cent., and down to 2 per cent., laid dust better than water, with a good binding effect; but there was considerable difference in the efficiency of different soaps. The best binders were resin soaps; but liquid soaps were of small value. The constituents of the soaps, and various chemical solvents of oil were also tried; many of these—*e.g.*, pyridine, carbolic acid, alcohol, carbon disulphide, Jeye's fluid, Walker's carbolacene—were efficient, but were objectionable on account of their offensive odor. The conclusions are that the special soaps of the Hull Oil Manufacturing Company are the best for wetting in 5 per cent. solutions; and liquid disinfectant soaps in 5

per cent. solutions. Fine dust is much more difficult to wet than coarse dust. The most efficient wetter and binder is a mixture of water-glass (sodium silicate), a resinous liquid soap (in 5 per cent. solutions), and commercial carbolic acid in the proportions 10:1:1. Dust thus treated is only inflammable with difficulty.

Mechanical Theory of Solar Corona. J. A. MILLER. (*Astrophys. Journ.*, xxxiii, 303.)—This paper gives the results of an investigation of the streams of the 1905 solar corona, undertaken with the intention of applying Schaeberle's mechanical theory. With a few slight modifications of the original assumptions, the main criteria were taken as considering the streams of the corona to be the projections, on a plane, of streams of particles, the motions of which are produced by ejection, modified by the rotation of the sun, by its attraction, and by the pressure of its radiation. The tests were made by careful measurements of the curvatures of the streamers recorded on the Lick Observatory eclipse photographs. In many cases the actual forms observed were in very close agreement with those calculated from the theory. One notable feature is the persistence with which the convex edge of a streamer is sharply defined, while the other is diffuse. The calculations also agree with the actual photographs in showing that the farther from the equator at which a streamer originates, the larger will be the eccentricity of the orbits of the particles composing the stream. The shape of the streamers will be a function of the inclination of the sun's axis to the line of sight.

Action of the Radium Emanation on Thorium Salts. MESSRS. HERSCHFINKEL. (*Mon. Sci.*, 838, 704.)—The conclusions are that the action of the radium emanation on thorium nitrate is not a phenomenon of atomic transformation, but of oxidation; for an oxidizer, such as potassium permanganate, also produces carbon dioxide, but in larger quantity than the radium emanation. The production of this acid, then, is not due to the transformation of an atom of thorium into carbon, as Ramsay thought, but doubtless results from an organic impurity, which is probably oxalic acid resulting from the treatment. It may therefore be deduced that an analogous cause may be discovered in the case of other substances which disengage carbon dioxide.

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